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C E N T E R

Technical Report

No. 13246

SLEEPING/RESTING EQUIPMENT FOR
COMBAT VEHICLE CREWS

(PHASE I)

CONTRACT NUMBER DAAE07-86-C-R070

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A current need exists to enable crews of combat vehicles to fulfill physiological needs while enclosed within a vehicle for periods of up to 72 continuous hours. Historically, soldiers have dismounted to find a suitable place to accomplish the restorative actions of sleeping, eating, exercising and relieving the stress associated with an operational situtation. Chemical, biological and/or radiation contamination present on the battlefield can make contact with the surrounding environment hazardous.

This study offers several conceptual hardware and training items which offer simple, straightforward solutions to the confinement problem. The concepts are in the form of individual, shared and vehicle generic items to facilitate effective crew sleeping and resting

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Sleep Psychology
Sleep Conditioning

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1.0. INTRODUCTION

This final report has been prepared by INVOTEC, Saugus, California, for the U. S. Army Tank-Automotive Command under Contract DAAE07-86-C-R070.

Phase I of the work consisted of a study and conceptualization of items for combat vehicle crew (CVC) resting and sleeping while enclosed in their vehicles for extended periods up to 72 hours as may occur during operations contaminated by nuclear, biological or chemical (NBC) agents, or in waiting times under the immediate threat of use of such agents.

The sleep-rest problem was addressed assuming the "worst-case" confinement situation of the crew in full protective chemical-biological (CB) gear, the Mission Oriented Protective Posture (MOPP)4 ensemble with gas mask, hood, outergarment, gloves and boots. Additionally, the crewman will have his armored vest under the CB gear.

The M1, M2 and M3 armored vehicles were used as models of seating and space available for the individual and in common shared interior volume.

2.0. OBJECTIVES

The technical objective was to define the problem of sleeping and resting while confined in the seats and common space available within enclosed combat vehicles. The result of the work was to prepare conceptual designs and to fabricate prototype hardware facilitating resting/sleeping of enclosed combat vehicle crews.

The primary goal was to develop lightweight, rest/relief equipment for combat vehicle crews which can be used in existing vehicles without modification and minimal training of personnel.

The CVC sleep/rest study scope is outlined in Figure 2-1.

Specific objectives of the work were:

- Perform a literature search on the confined CVC sleep/rest problem
- Design concepts for techniques and equipment for CVC sleeping/resting in closed vehicles

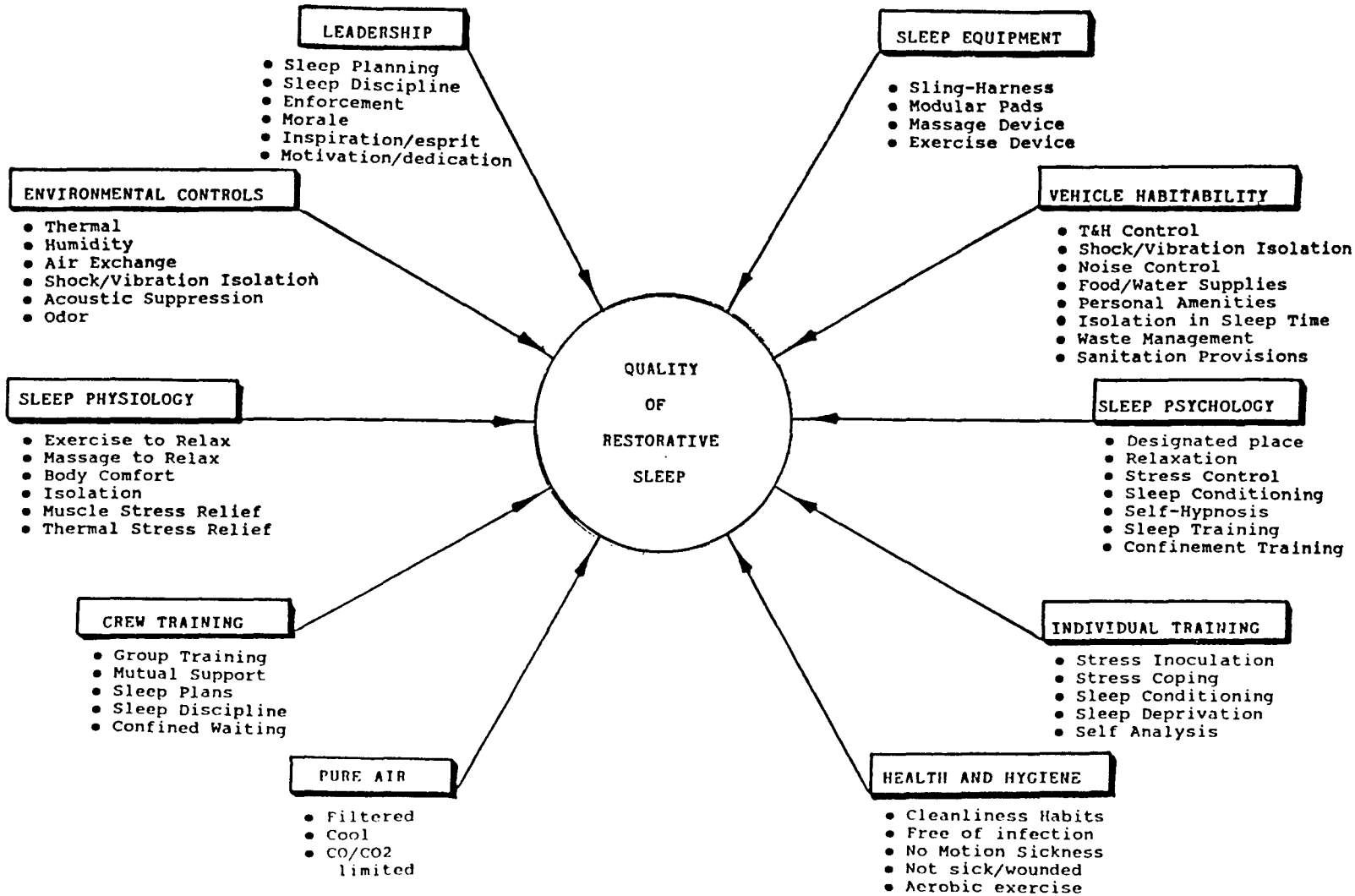

Figure 2-1. Sleep/Rest Study Scope

- Conduct trade studies and analyses to optimize designs as related to three vehicles of interest: M1A1 Tank, M2 Infantry Fighting Vehicle (IFV), and M3 Cavalry Fighting Vehicle (CFV)

- Standardize the equipment for universal use within the three types of vehicles

- Stress the sleep/resting situation of the CVC primarily, rather than the dismount squad of the M2 IFV

- Develop concepts of techniques to facilitate sleeping by the enclosed CVC

- Fabricate prototypes of the concepts for tests and demonstrations

- Perform testing and design analyses to evaluate effectiveness of the concepts in use

- Conduct trials in simulated vehicle compartments with mannequin and human subjects

3.0. CONCLUSIONS

3.1. Accomplishments

Sleep deprivation tests performed by the Army on combat crews were reviewed. The need for sleep planning and provision of certain amenities, including special equipment for sleeping inside "buttoned-up vehicles" by CVC's, were established. The crew and individual factors and problems involved in obtaining restorative sleep while confined within combat vehicles for long periods under combat stress were identified. Figure 3-1 illustrates the scope of the Phase I program.

During Phase I INVOTEC conceptual designs, fabricated and demonstrated the following items of CVC sleep/rest hardware:

- Sling-Harness (sleeping/resting support net), see Figure 3-2

- Modular Pad (individual-issue cushion capable of assembly into a variety of interconnecting multiple configurations with other pads and with the Sling Harness for body comfort), see Figure 3-3

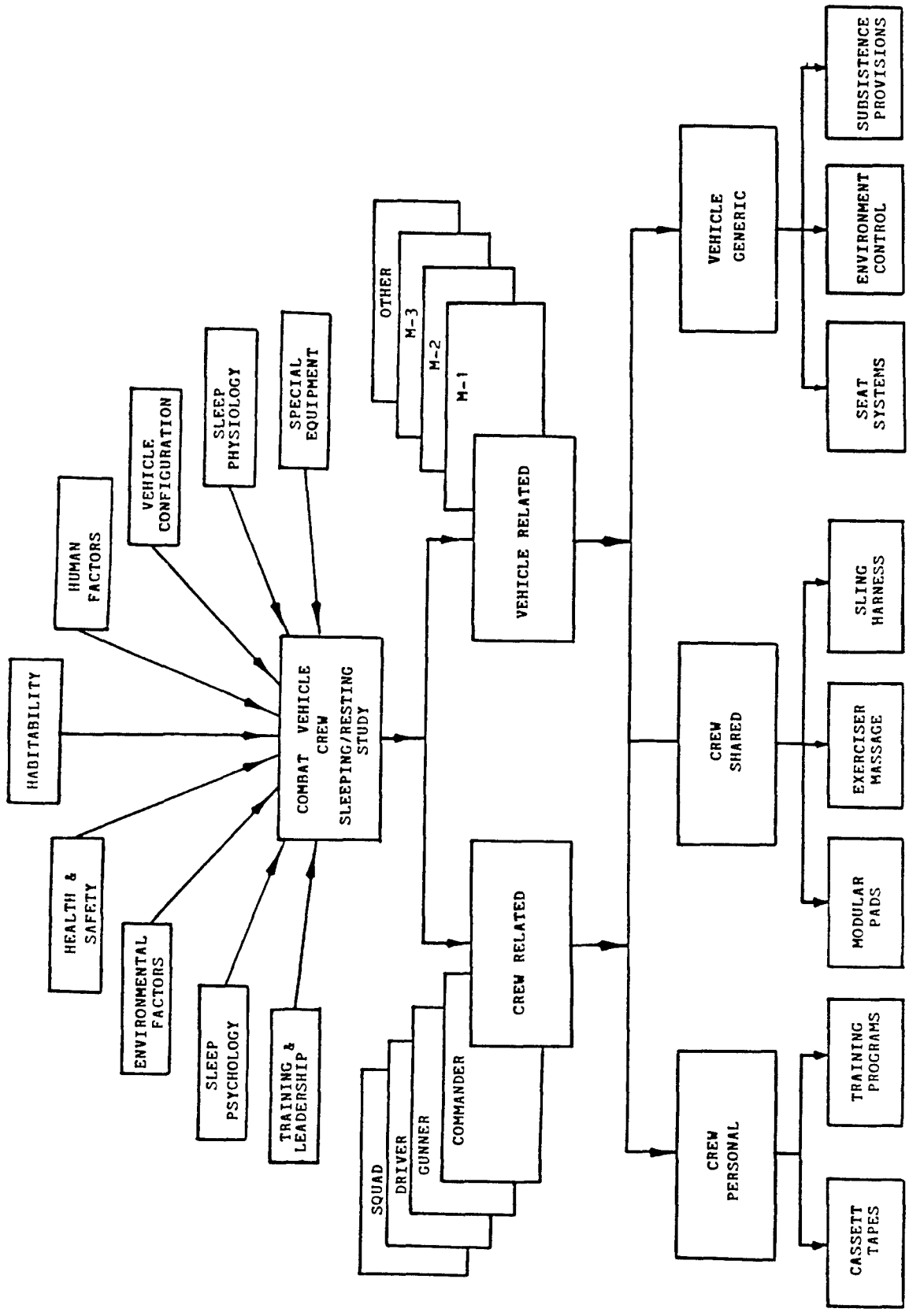

Figure 3-1. Sleep/Rest Equipment Development Plan

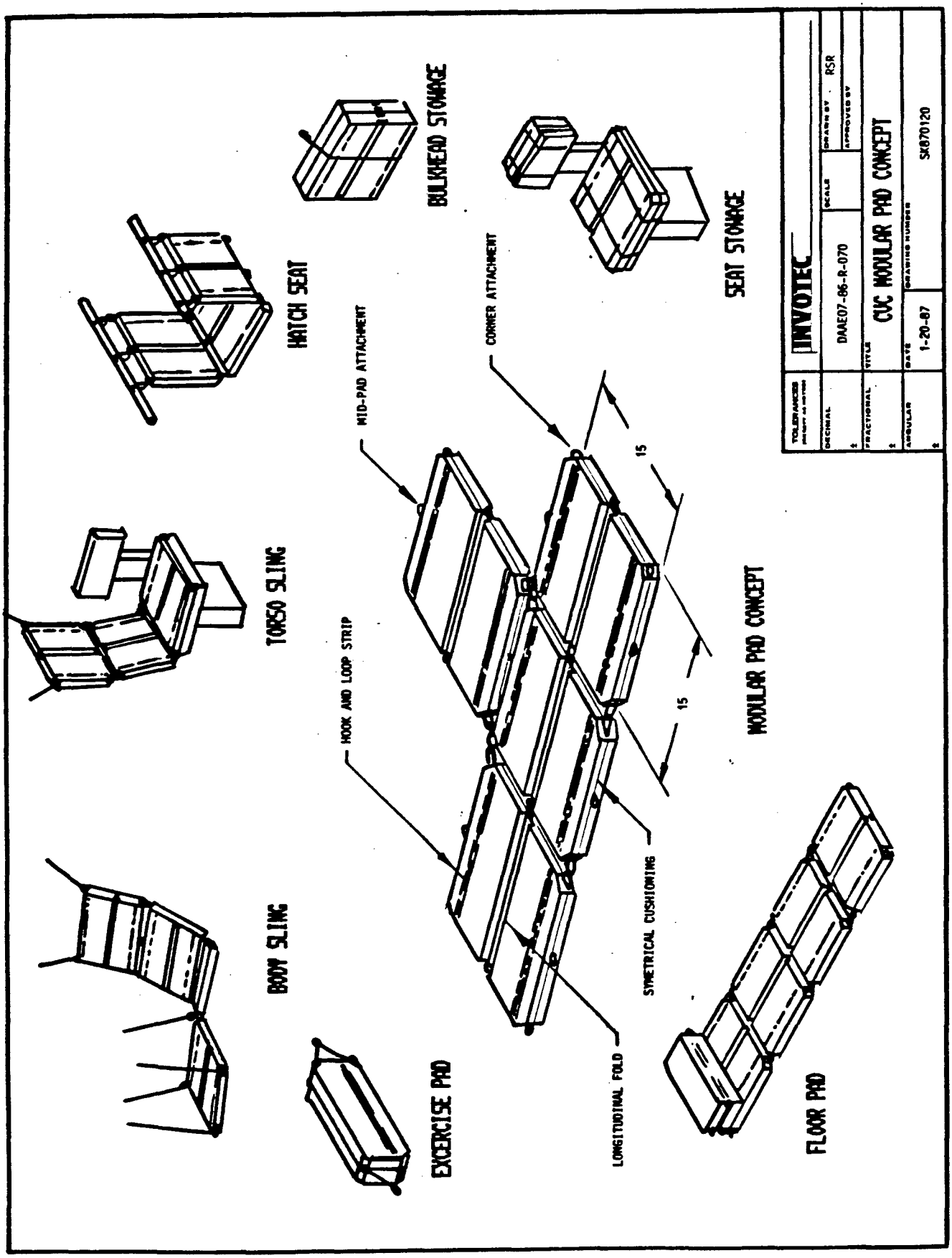

Figure 3-2. Modular Pad Concept

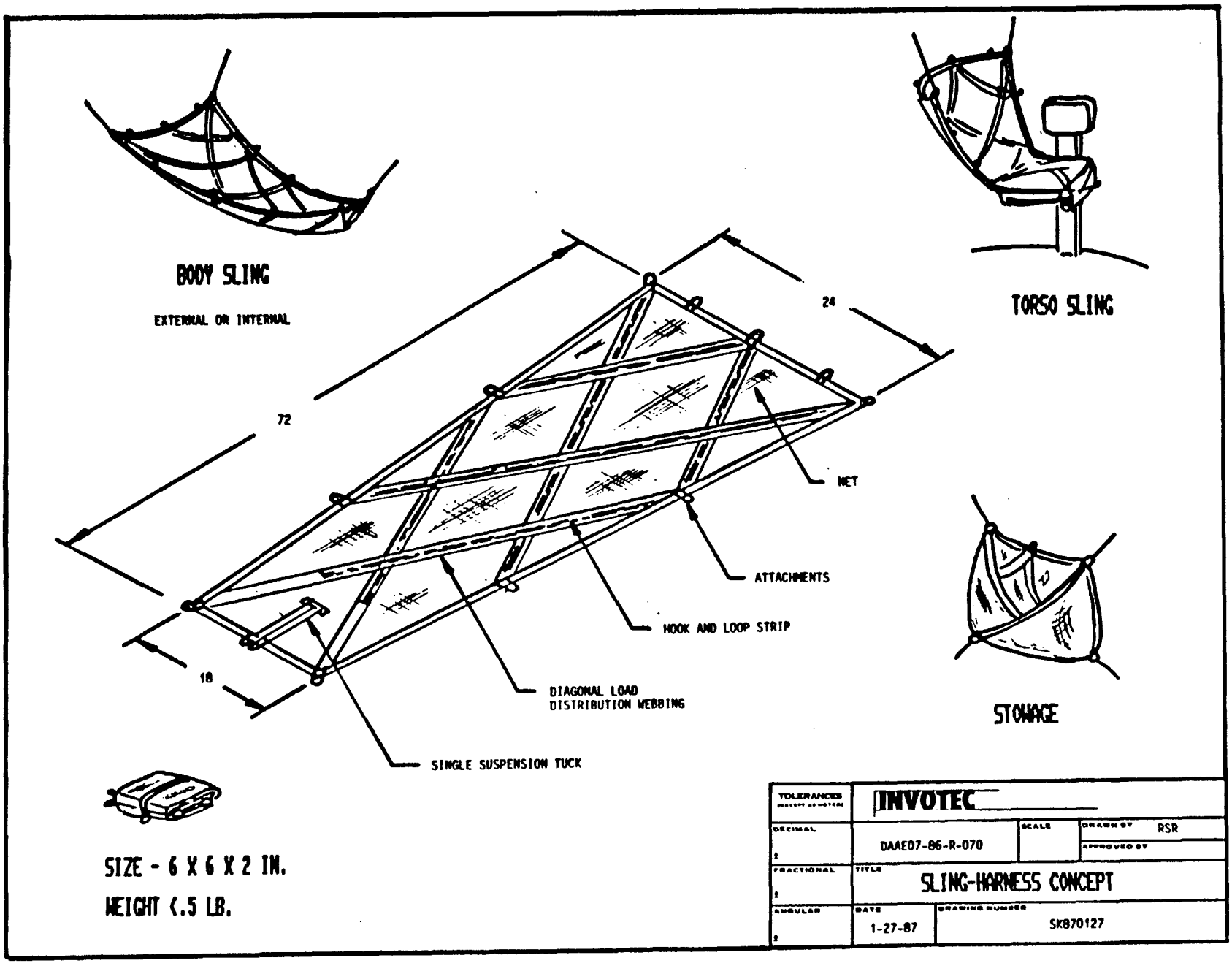

Figure 3-3. Sling-Harness Concept

- Extendable Bar (strong back for Sling Harness and hanger for commander's head-out seat), see Figure 3-4

- Exercise device (elastic cord assembly combined with Adjustable Bar), see Figure 3-4

- Massage Device (used alone or with rolled modular pad), Figure 3-5

- Relaxation/Sleep Conditioning Program Tapes (used with an audio-cassette player)

As a follow-on to the Phase I effort, INVOTEC recommends specific Phase II tasks which will result in service-grade hardware kits of sleep/rest gear and U. S. Army field evaluations of the hardware and techniques of use. After correction of any faults found in the Army evaluations, the sleep/rest hardware items can be defined in technical data packages and procured competitively without further development.

3.2 Findings

Interior spaces of the M-1 and M-2 combat vehicles were replicated in full-size wooden mockups. These mockups were used in installation trials of the conceptual hardware. The mockups are available for further fidelity enhancement as part of Phase II tasks. Table 3-1 summarizes the existing space conditions by crew position for each vehicle of interest in the study.

The study produced the following information relating to the CVC sleeping/resting while confined within a buttoned-up vehicle:

- Army doctrine envisions the future battle will consist of continuous operations, day and night until a decision is reached

- Troops in continuous operations, will decrease in effectiveness as a combat force with time

- Degradation of the individual soldiers from the multiple stresses of unrelieved combat is variable depending on both individual and group factors

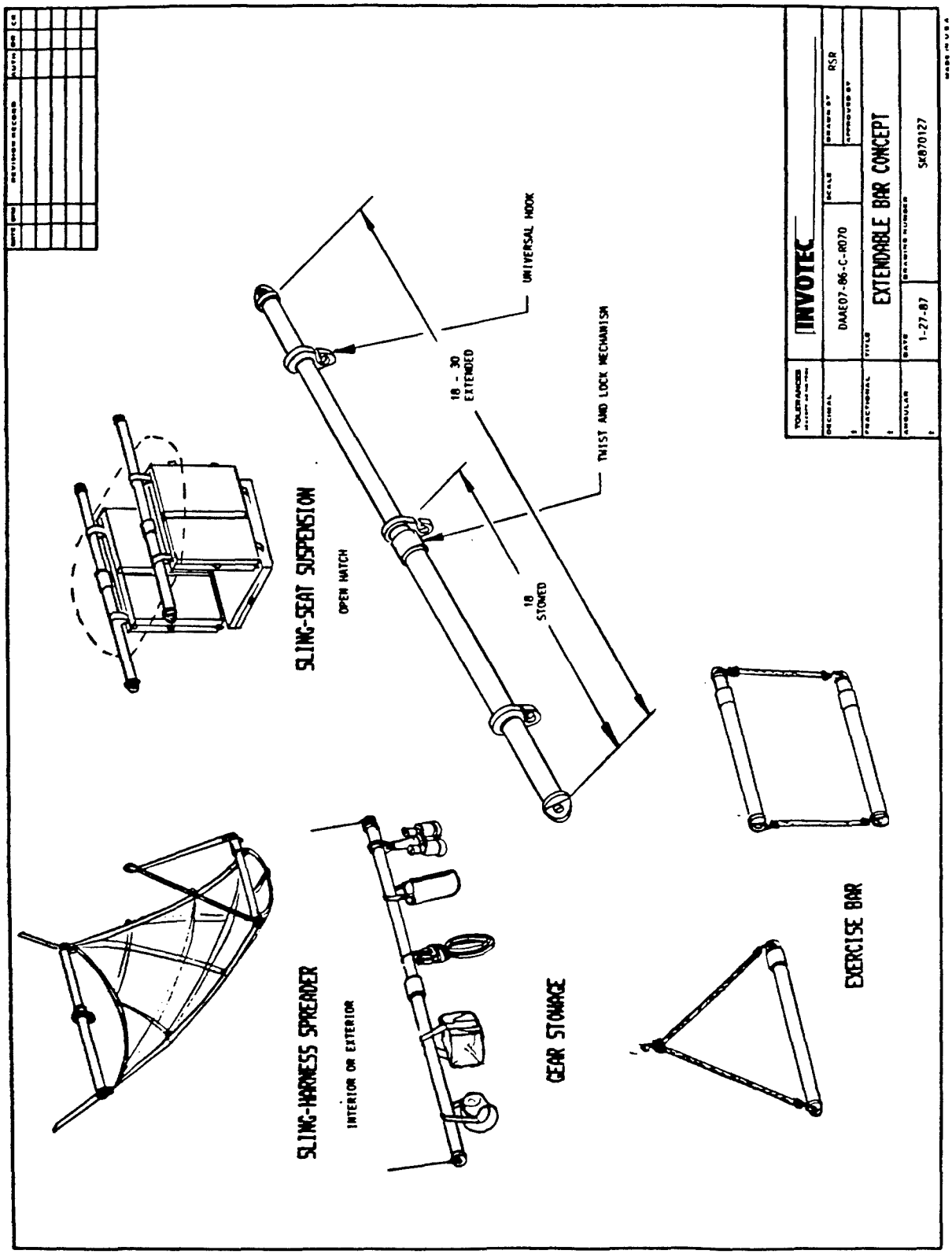

Figure 3-4. Extendable Bar/Exerciser Device Concept

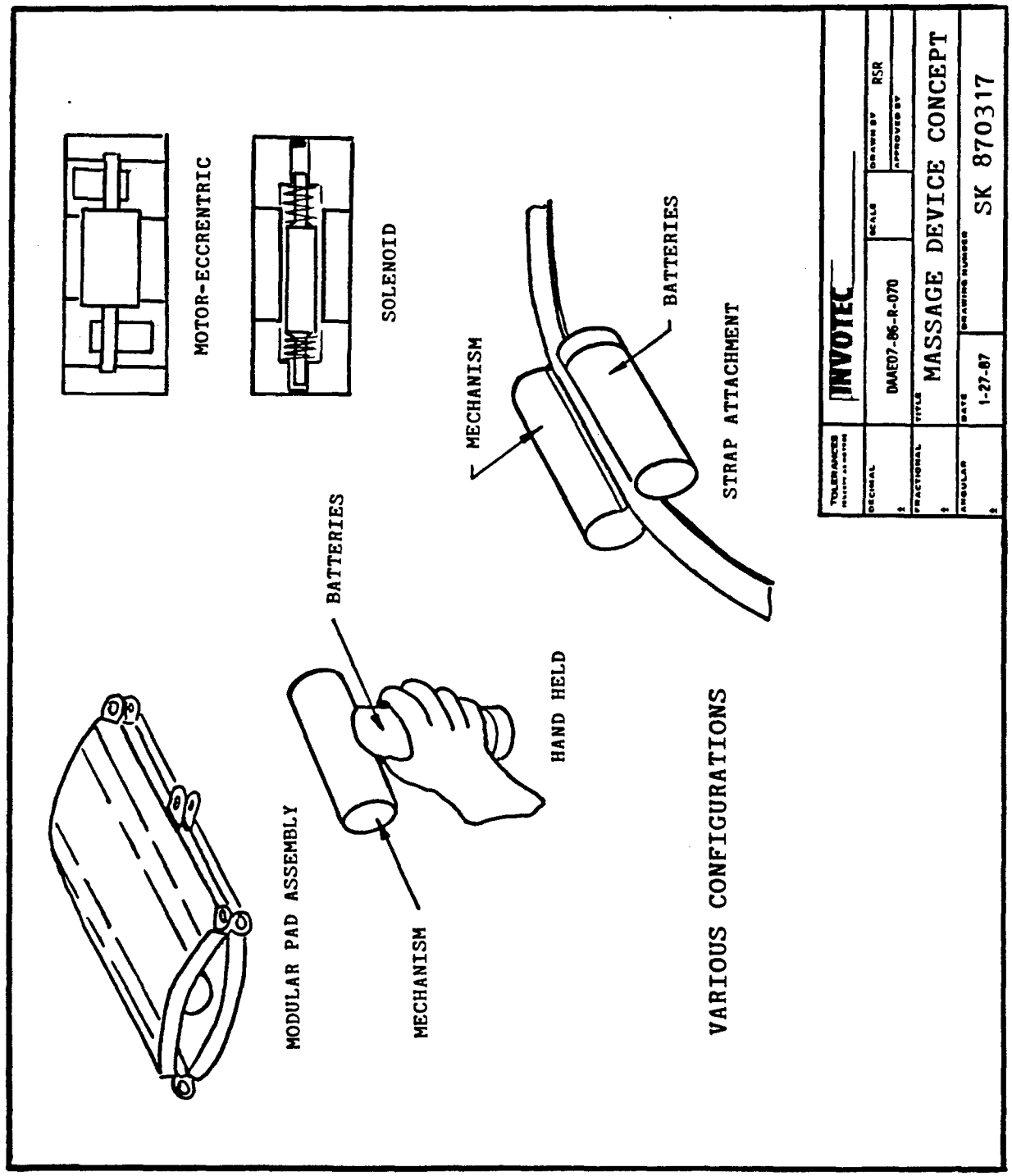

Figure 3-5. Massage Device Concept

Table 3-1. Combat Vehicle Crew Position Sleep/Rest Issues

VEHICLE	CREW POSITION	DUTY CYCLE / FUNCTION	CONSTRAINTS	DESIRABLE AMENITIES
M-1	COMMANDER	COMMUNICATION SOURCE ASSIGNS WATCHES MAINTAINS CONTROL ASSESSES CREW CONDITION	SIT OR STAND ONLY LIMITED STOWAGE SEAT BACK IS FIXED SEAT BOTTOM FOLDS AWAY FEET AT HEAD OF GUNNER	OPEN HATCH SEAT TORSO SUPPORT CUSHIONING
	GUNNER	LOW DUTY CYCLE INTENSE CONCENTRATION HIGH-STRESS POSITION	BODY RESTRAINT LEG ROOM SEAT BACK FIXED NO STOWAGE	HEAD SUPPORT CUSHIONING
	LOADER	LOW DUTY CUCLE HEAVY PHYSICAL WORK	NO EXTERNAL VIEW SIT OR STAND ONLY SEAT BOTTOM SWIVELS	CUSHIONING EXERCISER OPEN HATCH SEAT
	DRIVER	HIGH DUTY CYCLE ISOLATED FROM OTHER CREW SUPINE POSITION	SEAT FLATTENS HATCH RESTRAINED BY TURRET CANNOT SIT OR STAND	CUSHIONING
M2,M3	COMMANDER	COMMUNICATION SOURCE ASSIGNS WATCHES MAINTAINS CONTROL ASSESSES CREW CONDITION STAYS WITH VEHICLE	SIT OR STAND ONLY LOW HEADROOM RESTRICTED ACCESS LIMITED LEG ROOM LIMITED STOWAGE SEAT BACK FIXED	OPEN HATCH SEAT CUSHIONING TORSO SLING
	GUNNER	LOW DUTY CYCLE INTENSE CONCENTRATION HIGH-STRESS POSITION	SIT OR STAND ONLY LOW HEADROOM RESTRICTED ACCESS LIMITED LEG ROOM LIMITED STOWAGE SEAT BACK FIXED	OPEN HATCH SEAT CUSHIONING TORSO SLING
	DRIVER	ISOLATED POSITION HIGH DUTY CYCLE ISOLATED FROM OTHER CREW	SEAT NOT REMOVABLE CANNOT STAND UP	CUSHIONING EXERCISER
	SQUAD # 4,5	SIDE OF TURRET HAVE LEG EXTENSION	LIMITED STOWAGE LOW HEADROOM SEAT BACKS DO NOT RECLINE	CUSHIONING EXERCISER TORSO SLING
	SQUAD # 6-9	AFT AREA UPRIGHT SEATS NO LEG EXTENSION	LIMITED STOWAGE LOW HEADROOM SEAT BACKS DO NOT RECLINE NO LEG ROOM	CUSHIONING EXERCISER TORSO SLING

- Restorative resting/sleeping is vital to decision of the battle in the continuous, day-night operations now envisioned

- The degrading effects of sleep deprivation are cumulative and inexorable in the need to be "paid back" if military effectiveness is to be restored

- Leaders and others with cognitive functions (identifying, evaluating, deciding) degrade faster than those with physical duties

- Leaders need sleep priority, both as to quantity and quality

- Sleep planning and discipline are necessary in continuous operations envisioned

- Coping techniques help in relieving the effects of stress

Sleep planning has become an important factor in continuous operations to assure sufficient sleep according to the military need, cognitive character of the individual's responsibilities and each person's own requirements (rather than equality for all). Training and actual experience has to prove this so that men accept the inequality as militarily essential.

Restorative sleep is achieved in a complex interaction of individual, group (crew), environmental, situational, psychological, physiological conditions in which pre-planning, actual experience, leadership and teamwork combine as elements in the solution.

Army-issue equipment for sleeping in the field consists of sleeping bags, foam pads and inflatable air mattresses. No special equipment for sleeping while enclosed within vehicles exists in the inventory.

Current combat vehicles are not equipped for long-term habitability:

- Water reservoir capacity is not sufficient for the entire crew for three days of confined occupancy

- Air filtration is for particulates only; carbon monoxide and carbon dioxide are not removed

- Crew station seats and common space inside the current combat vehicles were not designed for long periods of occupancy under buttoned-up conditions

- Interior space is limited and cramped; storage space is minimal, distributed in random locations and volumes

Except for the M1A1 Tank, at the time of the study, no combat vehicles are equipped with microclimatizer equipment to cool the CVC in hot weather.

Troops have not been trained for, nor have they practiced, long-term confinement in buttoned-up vehicles.

The combination of high temperature and heavy workload makes the NBC ensemble unbearable in a few hours unless the microclimatization cooling is provided to each man.

The quality of sleep can be improved by : body support, cushioning, exercise for aerobic fitness, massage for relaxation and psychological conditioning for stress control, relaxation and sleep.

Although space is at a premium in all vehicles, stowage of the proposed sleep/rest equipment is feasible.

Interior layouts of vehicles are different; great differences exist even between models of the same type.

Seats are not standardized and differ from vehicle to vehicle and within vehicles by crew position.

Additional gear introduced into the vehicle should be compact, lightweight, safe, durable, easy to use, storable in odd shapes, and have multiple applications, preferably, in addition to their use as sleep aids.

Table 3-2 rates the sleep/rest hardware equipment factors as to functional merit.

4.0 RECOMMENDATIONS

4.1. Sleep Equipment

Specialized equipment for CVC relaxation and comfort, to the degree possible in the confined space available, should be provided. Such items are as follows:

Table 3-2a. Sleep/Rest Equipment Factors

FACTOR	CASSETTE TAPES	MODULAR PADS	SLING-HARNESS
STOWABILITY	EXCELLENT - Each crewman provides stowage with personnel items.	GOOD - Modular pads can be stowed folded in open spaces, on bulkheads or on overhead with elastic cords.	GOOD - Sling harness folds or rolls into a very small package which is easily tucked into open space.
VEHICLE COMMONALITY	EXCELLENT	EXCELLENT	EXCELLENT
CREW FREEDOM TO MOVE/ACT IN AN EMERGENCY	EXCELLENT NO ADVERSE EFFECT	FAIR -Pads should have designated stowage spot so as not to interfere with operational capability	POOR - Sling harness must only be deployed when combat operations are not imminent, some means to provide retraction may be provided.
EASE OF DEPLOYMENT-REMOVAL	EXCELLENT	GOOD - Pads are designed to be folded in the attached mode, pads may become seat or back cushions.	FAIR - Sling harness must have designated attachment points.
MULTIPLE APPLICATIONS SECONDARY USES	EXCELLENT - Tapes my be customized by crew to provide optimun sleep-rest effect.	EXCELLENT - A minimum of five other functions: (1) floor cushion (2) torso sling, (3) sling seat, (4) massage cushion, (5) exercise pad.	GOOD - A minimum of three functions: (1) body sling, (2) stowage device, (3) exterior hammock.
TRAINING REQUIREMENTS	GOOD - Some form of training should be provided in order to optimize effect of tapes. Also need guidelines for use of communication system.	GOOD - Operating instruction should be provided to show all potential applications.	GOOD - Operating instruction should be provided to show all potential applications.
VEHICLE COMPATIBILITY	EXCELLENT	EXCELLENT	GOOD - Need to define specific locations and attachment means.
CREW SHARED VS. INDIVIDUAL	INDIVIDUAL AND SHARED	INDIVIDUAL AND SHARED	SHARED
POWER REQUIRED	INTERNAL BATTERIES VEHICLE BATTERIES	NONE	NONE
SUITABILITY TO VARIOUS SEATS AND VEHICLES	EXCELLENT	EXCELLENT - Crews can be innovative.	FAIR - Locations should be specific.

Table 3-2b. Sleep/Rest Equipment Factors

FACTOR	EXCERCISE DEVICE	MASSAGE DEVICE
STOWABILITY	EXCELLENT - No extra hardware is required. Bungees provide stowage restraint for other items	GOOD - Small size and shared item, one per vehicle.
VEHICLE COMMONALITY	EXCELLENT	EXCELLENT
CREW FREEDOM TO MOVE/ACT IN AN EMERGENCY	GOOD	GOOD - Stows with modular pads
EASE OF DEPLOYMENT-REMOVAL	GOOD	EXCELLENT
MULTIPLE APPLICATIONS SECONDARY USES	GOOD - Bar is useful with modular pads and sling harness.	POOR - Single use only
TRAINING REQUIREMENTS	GOOD - Operating instruction should be provided to show all potential applications.	EXCELLENT - No instructions needed.
VEHICLE COMPATIBILITY	EXCELLENT	EXCELLENT
CREW SHARED VS. INDIVIDUAL	SHARED	SHARED
POWER REQUIRED	NONE	BATTERIES OR VEHICLE POWER
SUITABILITY TO VARIOUS SEATS AND VEHICLES	EXCELLENT	EXCELLENT

- Sling-Harness for individual use in place at the station seat or on a time-shared basis in the common space

- Modular pads for use as cushions singly or in assemblies with other pads and/or into the Sling-Harness

- Exercise device for muscle relaxation and aerobic fitness

- Massage device to stimulate blood circulation and muscle relaxation

- Cassette tape player with audio programs for psychological conditioning for relaxation, to induce sleep onset, provide entertainment, present training subjects and relieve boredom

4.2. Troop Training in Enclosed Operations

Special training of combat vehicle crews should be developed for extended confinement inside closed vehicles including:

- Screening tests to eliminate individuals unable to cope with confinement for long periods

- Psychological training in relaxation, stress control, sleep techniques, and individual coping procedures (tailored to individual needs)

- Minimum-space exercising techniques for aerobic fitness

- Graduated exposure to long-term confinement

- Use of specialized sleep equipment

4.3. Psychological Conditioning of CVC's

The study identified the need for audio cassette programs that can be adapted into a crewman's headset or networked into the vehicle's intercom system. The cassette tape can be used by the individual crewman or, at the discretion of the commander, for full crew relaxation programming, training, morale messages and off-duty entertainment.

Future vehicles might have a flat-screen video at one or more locations within the vehicle. The video equipment will used for training in military subjects, motivational exhortations,

psychological conditioning, and recreational purposes, providing a wider range of stimuli than audio-alone programs.

A source of micro-video screens which are intended for airline passenger seatback installation has been identified. This hardware could be adapted for existing and/or future combat vehicle use.

4.4. Habitability of Vehicles

Existing vehicles need to be retrofitted to provide:

- Pure air supply
- Microclimatization for each crew member
- Increased quantity of water with convenient dispensing spigot and chilling provisions
- Water heating device (24-volt access inside vehicle) for warming meal packets
- Connector provision for cassette tape player at each CVC headset (to play individual relaxation/sleep conditioning tapes) and also at commander's station control box for all-station conditioning messages
- Additional hardpoint attachments (footman's loops) convenient and specially located for sleep/rest gear suspension within the vehicle

4.5. Militarization and Detail Design

Further work is needed to:

- Militarize and standardize the sleep/rest devices
- Ruggedize the items, proving structural and environmental qualification
- Prepare psychological conditioning programs tailored to the enclosed and operational CVC
- Prepare training materials for use of the sleep/rest equipment by the CVC

4.6. Field Testing

Field testing of prototype sleep hardware is proposed for the Phase II effort. Here, kits of equipment for various vehicles will be assembled and delivered to the Army Boards (Armor, Infantry) and other agencies (Human Engineering Laboratory, and 7th Division) for service use and evaluation. Findings from troop experience would be used to finalize the prototype designs.

4.7. Further Recommendations

The Phase I effort has indicated that the sleep problem has ramifications beyond the scope of the original Phase I and proposed Phase II work. Additional factors beyond sleep/rest aids affect the achievement of restorative sleep for combat vehicle crews These factors include:

- Provision of crew cooling for high-temperature environments (climatization for all combat vehicles or crew stations)
- Provision of fresh air (removal of carbon dioxide and carbon monoxide as well as particulates), with odor control desirable
- Provision of an adequate supply of chilled potable water (sufficient quantity for 3-5 days)
- Design of crew seats for standardization and inclusion of resting gear as part of the primary cushioning
- Establishment of CVC sleeping/resting criteria as a prime requirement in the specifications of future vehicles
- Recommend concepts for CVC seating systems appropriate for future vehicles

In connection with the last recommendation, the future seat systems would not only provide all the functional requirements for operational use but would be adjustable, stowable, and contain extended habitability equipment and provisions.

5.0. DISCUSSION

5.1. General

Historically, until the development of night vision equipment, crews of armored vehicles fought in daylight only, and dismounted to rest and relieve themselves, operating when buttoned-up only in direct contact with the enemy, and then only when counterfire made open-hatch maneuver hazardous.

Current armored tactics envision continuous operations, with the battle persisting at an intense level around the clock without let up until the battle is decided. Harsh, savage engagements with great losses of material, personnel and logistics assets will characterize the battle. Such continuous land combat operations are possible due to:

- Almost complete mechanization of forces
- Saturation of the battlefield with armor
- Ability to move/fight effectively at night, thus denying armored forces the dark period for withdrawal from battle and rest
- Probable use of chemical and nuclear weapons to contaminate the environment of battle

In the extended region of battle, the forward edge is indistinct and the battle zone deep sectored so there are no fresh troops at hand for relief of those heavily engaged; all are engaged. Sleeping on a regular basis is vital.

5.2. Vehicle Habitability

It is apparent from examining the interior of several armored vehicles that the seating and space within them were never intended for prolonged confinement. The existing vehicle seats are functional only for upright body support. They fold down or rotate away to maximize floor space when not used as seating.

Three stages of habitability improvement are needed:

- Establishment of stowage methods and utilization of available random space for sleep equipment within existing vehicles

- Incorporation of stowage of the sleep/rest kit into existing seat hardware and/or seat locations

- Preparation of concepts of a seat system appropriate for long-term enclosed operations by future vehicles

The ultimate approach is to design a standard CVC seat system which combines the sleep/rest functions and habitability features within the seat. Such as seat would be a generic type used in all combat vehicles. The design would follow the philosophy of aircraft-crew seats where the seats can be easily changed out depending on the desired configuration.

For future vehicles, INVOTEC envisions armored vehicle seats, designed and furnished similarly to aircraft crew-escape seats, a system within itself, provided as Government furnished materiel (GFM) to the vehicle manufacturer. Future vehicle specifications would contain envelope and interface requirements which are compatible with the generic seat design.

The seat would include the features of microclimate cooling/heating, modular pad stowage, ration stowage, personal gear stowage, exercise capability, sanitation, waste management, head-out/buttoned-up sitting options, and reclining postures for resting modes.

5.3. Performance Degradation from Sleep Deprivation

Sleep deprivation causes progressive performance degradation. Intense combat provides high stress and accelerated performance degradation. Performance on a duty position where there is a heavier load of mental tasks (determining, calculating, thinking, decision making) degrades more rapidly under sleep deprivation than the duty performance of physical tasks (e.g., firing weapons, running, lifting, digging). Tank loaders, occupied with physical service of the main gun will function better longer than the rest of the crew.

Thus, command and control, erodes under conditions of sleep deprivation, and when leaders begin to fail, the organization disintegrates. To keep an adequate level of command/control during continuous operations over extended periods of days, it is essential that the unit have sleep plans and the crews have discipline to follow the plan so that sleep opportunity is given to every man, but with priority to those involved in mental tasks to preserve the quality of leadership decisions and judgemental/evaluating actions.

In the past, the military tradition has tended to project the image of the leaders as "iron men" able to withstand battle rigors without sleep over many hours. This performance is no longer realistic in the 24-hour-per-day battle scenario. Sleep deprivation is no longer a personal inconvenience. In continuous operations the effect on leaders and persons making judgemental decisions is devastating to the military mission.

Restorative sleep is essential to tactical success in a battle involving continuous operations. Against an enemy equipped with equal technology, equally motivated, the outcome can be decided by the force which is most fit physiologically and psychologically as time elapses.

Figure 5-1 quantifies the projected performance degradation of tank crews in continuous operations when deprived of sleep.

The effects of sleep deprivation on human performance are:

- Decreased vigilance
- Reduced attention
- Slowed perception and comprehension
- Diminished ability to concentrate
- More faulty memory
- Slowed responding
- Increased omissions

The individual exhibits fuzzy reasoning, has difficulty in communicating, experiences mood changes, is quick to anger and sometimes is unaware of the changes in behavior which have occurred.

Men will sleep if they are tired enough in spite of danger and/or physical discomforts of their location. For continued military effectiveness in sustained operations, such random ad hoc arrangements for sleeping is inadequate for the long-term.

Restorative sleep depends on:

- Opportunity and permission
- A measure of comfort

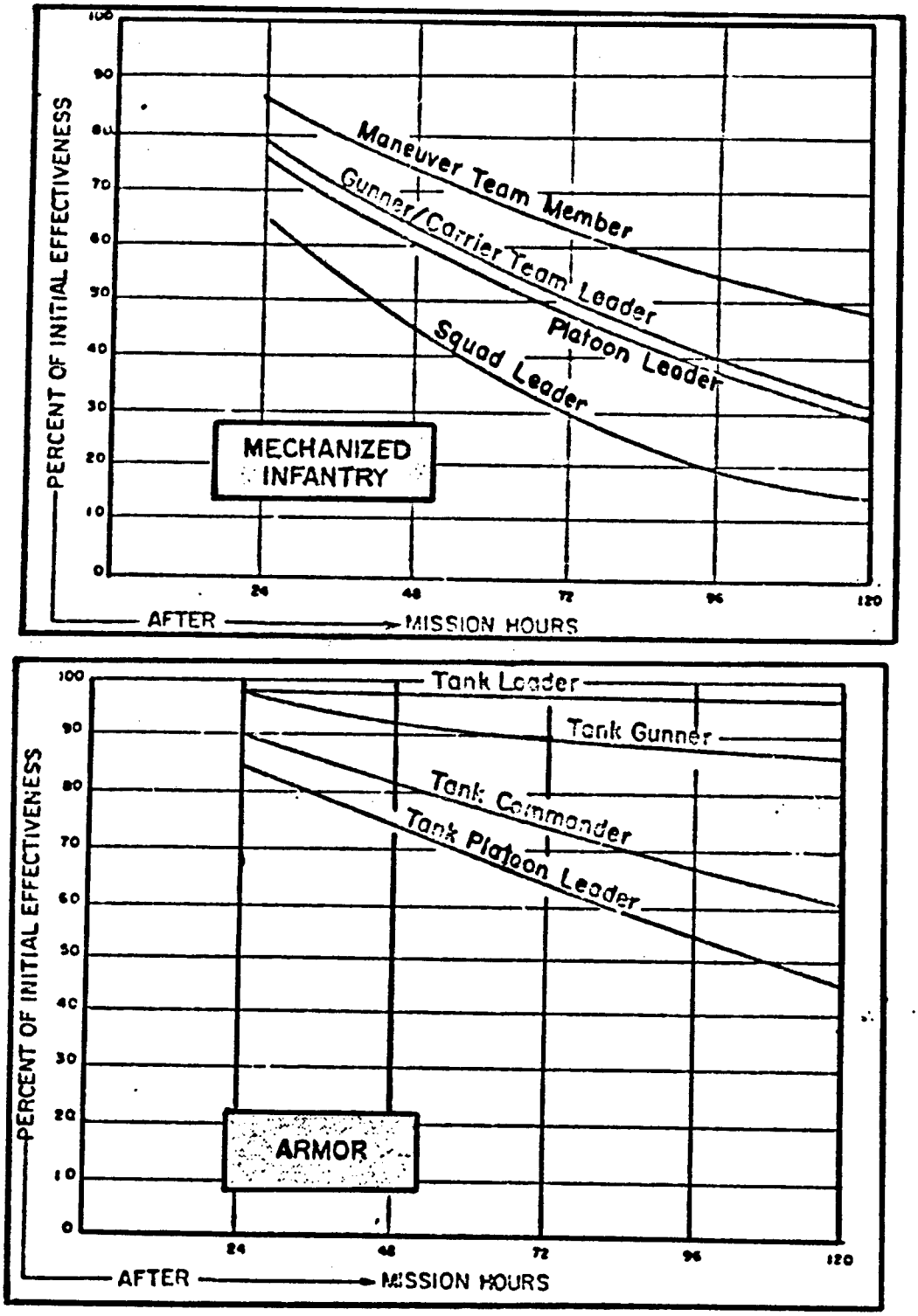

Figure 5-1. Projected Performance Degradation

- Pure air
- Moderate temperature (warmth/coolness as appropriate)
- Isolation from distracting environmental stimuli (sights, sounds, smells, shock/vibration)
- Opportunity for undisturbed solitude and knowledge that the period will not be violated except in an emergency
- Allowance of space ("territory") which will not be violated casually by others
- Psychological conditioning to accept the existing condition through training and experience
- Self-control (stress management) to relax in spite of the threats of the situation
- Provision of exercise to maintain aerobic fitness, muscle tone, strength and blood circulation (to prevent blood pooling in the lower body)
- Provision of mental stimuli, distraction, self-hypnosis, imagery, entertainment, etc.,conditioning the individual for sleep
- Provision of physical stimuli (massage) for relaxation of muscle tension and a degree of comfort
- Creation of physical and mental conditions to facilitate the onset of sleep
- Existence of a sleep plan for the unit and crew giving priority sleep (opportunity and quality) to those with cognitive responsibilities: leaders, commanders, gunners
- Awareness of the sleep plan by all crewmen and acceptance of the inequalities in its priorities
- Disciplined enforcement of the sleep plan to assure CVC combat effectiveness
- Designation of certain areas as sleep zones for exclusive use of designated sleepers

In this perspective, sleep inside the tank has tactical implications equal to marksmanship in the decisive engagement. Actions to obtain restorative sleep become a combat skill.

5.4. Countering Degradation from Sleep Deprivation

The strategies and tactics of developing resistance to personnel degradation under continuous combat operations include:

- Strategies: Building endurance of effective performance by:
  - Leadership
  - Training
  - Physical conditioning
  - Commitment
  - Talent selection
  - Resources management
- Tactics: Application of countermeasures to slow degradation by:
  - Task restructuring
  - Rotation
  - Work/rest cycles
  - Performance support
  - Stress management
  - Sleep discipline

The objective in sleep discipline is to provide a capability in the CVC to operate in battle continuously without mental degradation. The important aspects are:

- Counteracting sleep-loss effects
- Setting priorities for sleeping/resting
- Develop unit work/rest/sleep plans/schedules
- Enforcing discipline.

Sleep has to be managed; everyone has to get a fair share. For leaders, a fair share is more and/or better quality sleep.

Work/rest/sleep cycle are driven by the tactical situation but the grind of continuing battle cannot be allowed to deprive the combat crews of needed sleep. Sleep deprivation degrades performance of friendly forces drastically after 24 hours.

Techniques for counteracting sleep-loss effects include:

- Frequent naps where sleep periods are uncertain
- Periodic breaks, to include mild physical exercise and recreation
- Task rotation among cross-trained men in routine jobs
- Task rotation on complex tasks only when members are highly trained and fully qualified
- Design of military systems to compensate for types of errors likely to occur
- Hot food or beverages/stimulants

5.5. Sleeping Techniques

The provision of special equipment to facilitate CVC resting/sleeping is essential to the achievement of sleep for psychological and physiological reasons. First, the cramped, crowded and public situation of sleeping inside the vehicle is not conducive to sleep in any way. The equipment, if perceived as beneficial, helps the crewman in achieving the relaxation and mental acceptance that sleep is possible and allows the onset of sleep as a physiological event.

Three kinds of equipment for sleeping/resting were considered:

- Individual items--These are items which apply to individual crewmen, regardless of the vehicle type, crew station or function. They are provided to the crewman during vehicle qualification training and can be personalized to suit the individual. Such items are:
  - Ear plugs to isolate the individual from sounds
  - Eye shades to shut out light
  - Cassette tapes with individualized sleep-conditioning programs

- Cassette tape player with connector to attach to the CVC helmet earphones

- Training for sleep conditioning and use of sleep/rest equipment

- Crew-shared items--These are items used by more than one crewman in turn, on a shared basis. In the combat situation, it is expected that no more than 50 percent of the crew would be off alert at a given time. Therefore, a vehicle kit of sleep/rest hardware would be provided to support half the CVC.

An equipment kit for each type vehicle might be as follows:

VEHICLE TYPE	COMMUNICATIONS ADAPTER	MASSAGE DEVICE	MODULAR PADS	EXERCISE DEVICE	SLING-HARNESS
M1	4	1	8	1	2
M2	3	1	12	1	3
M3	3	1	8	1	2

- Vehicle generic items -- These are equipment items which are vehicle integral systems. Examples include: auxiliary cooling equipment, machinery, water supply, environmental controls, lighting, subsistence provisions, seating, and so forth.

5.6. Sleep/Rest Equipment

5.6.1. Sling-Harness. INVOTEC sent inquiries to six manufacturers of commercial hammocks; no response was received which would be suitable for the CVC application. A requirements document was generated and concepts solicited for hardware to be fabricated in accordance with Figure 5-2.

An initial prototype was received which incorporated a novel, open-weave synthetic netting of very light weight and excellent strength. Trials with this initial prototype in the vehicle interior mockup resulted in changes and modifications providing the following features:

- Diagonal load distribution. The netting stretches and the load is taken entirely by the reinforcing webbing. A method of distributing the load into the netting was required

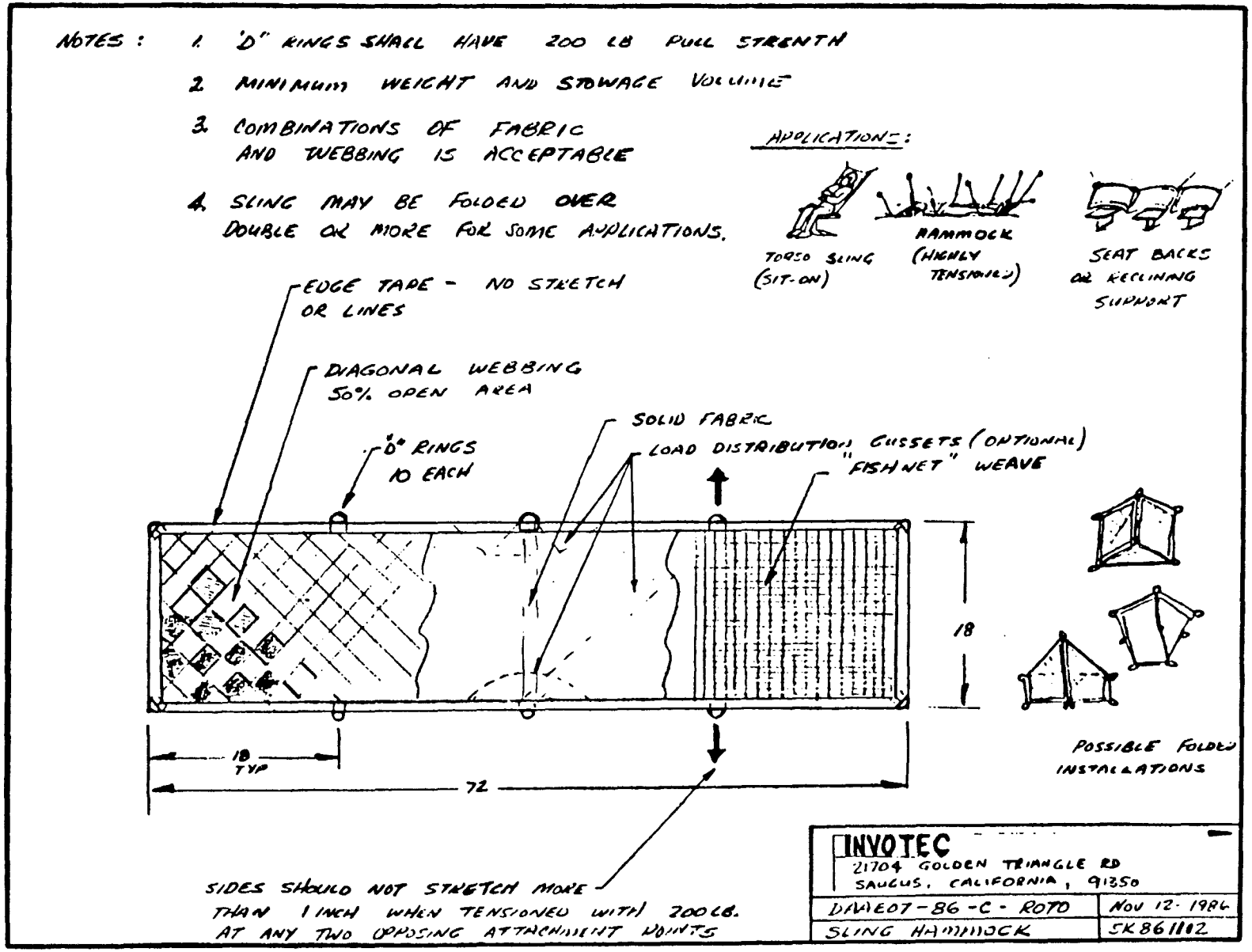

Figure 5-2. Sling-Harness Concept Requirements

- The Sling-Harness should have provisions for body retention/restraint. A trapezoidal shape provides raised side panels for the upper torso.

- Means of attaching the Modular Pads to the Sling-Harness

Three additional concepts incorporating the above features were obtained: The four prototype designs are shown in Figure 5-3.

Items to be considered for further capability enhancement include:

- Additional and wider diagonal support webbing to increase the load distribution into the netting

- Velcro strips to attach Modular Pads to the harness

- Use of an INVOTEC-designed one-piece attachment instead of D-rings

Table 5-2 is a matrix of the various Sling-Harness design considerations.

The Sling-Harness concept is useful in the vehicle confinement sleep/rest scenario. A Sling-Harness permits an off-watch crewman to assume a nonseated position to rest and sleep. Although the internal space is severely limited inside the armored vehicles, several installation options have been identified.

Space in the turrets of both vehicles (M1 and M2/M3) allows horizontal deployment of the Sling-Harness and near full-length stretchout of a crewman. The passageway to the left of the turret in the M2/M3 vehicles can be vacated, allowing full-length horizontal use of the Sling-Harness.

In the cases where the soldier must use the Sling-Harness in his seat, the suspension of his weight off the buttocks provides skeletal and muscle relief. Any degree of inclination off vertical also helps.

The INVOTEC concept of the Sling-Harness is that it be a net/fabric appliance, adaptable/adjustable/suspendable in a variety of ways within the combat vehicle compartment to support the crewman's body in more comfort than normal seating. The Sling-Harness can be suspended from the

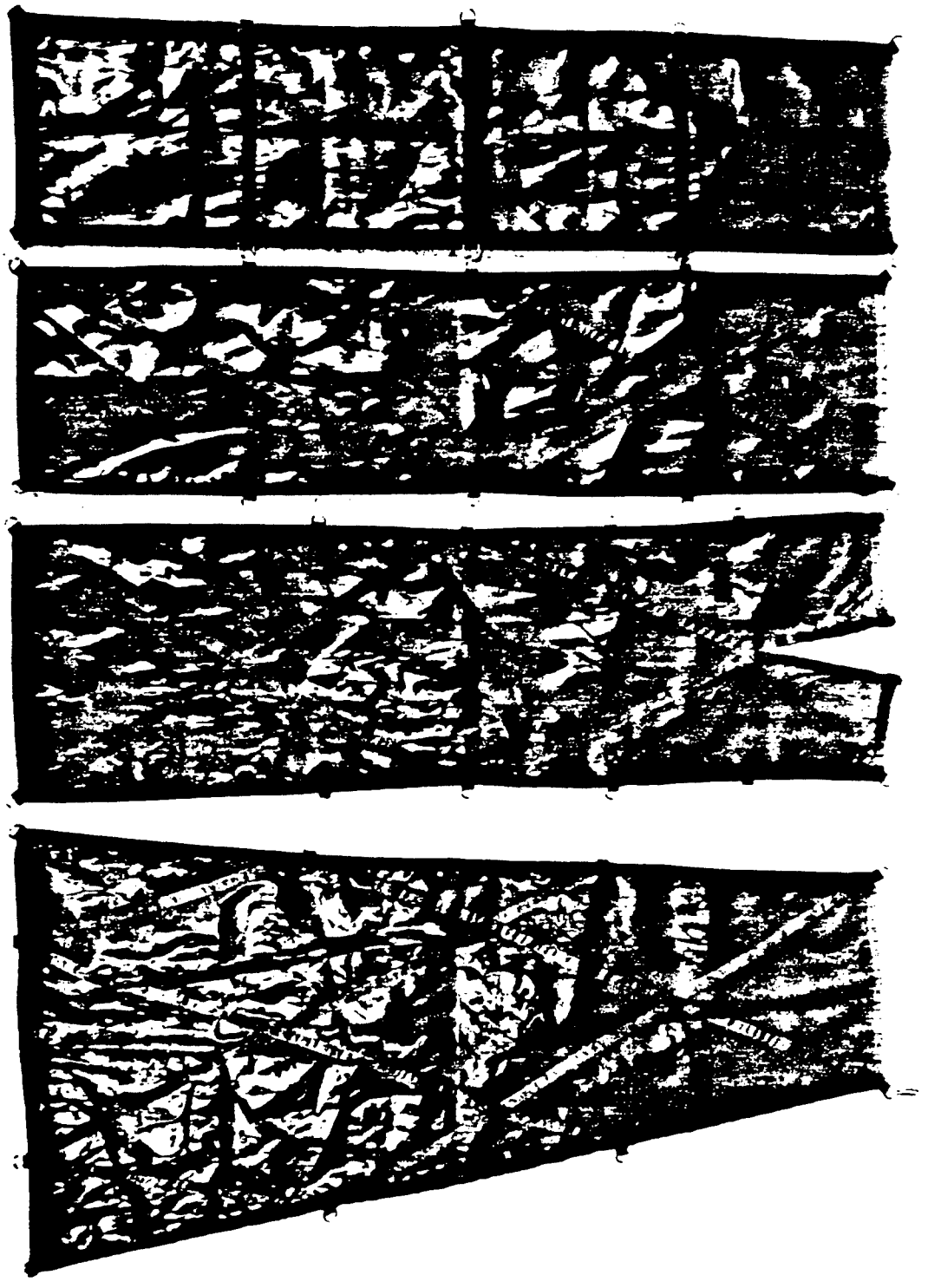

Figure 5-3. Sling-Harness Concept Prototypes

Table 5-2. Sling-Harness Design Considerations

SLING ELEMENT	ITEMS/MATERIALS CONSIDERED	DESIRABLE CHARACTERISTICS	CONCEPT SELECTED
BACKING	FABRIC NETTING CROSS WEBBING	LIGHTWEIGHT DURABLE MINIMUM STRETCH NONFLAMABLE EASILY STOWED SOLVENT RESISTANT	SYNTHETIC NET OPEN WEAVE
TRUSS	WEBBING ROPE WIRE NETTING	TENSILE STRENGTH MINIMUM STRETCH ATTACHABLE	NYLON WEBBING
ATTACHMENTS	D-RINGS HOOKS LOOPS GROMMETS	GLOVED OPERABLE SIMPLE SYMMETRICAL ATTACHMENT QUICK RELEASE	INVOTEC DESIGN CLIP
SHAPES	RECTANGLE TRAPEZOID TRIANGLE TEE SQUARE TUCKED ENDS	5 - 95 PERCENTILE CREW SUPPORT DURING TRANSIT BODY LIMB RESTRAINT EASY/QUICK EXIT	TRAPEZOID WITHOUT TUCK
APPLICATIONS	WHOLE BODY SLING UPPER TORSO GEAR STOWAGE OPEN HATCH SLING SEAT VEHICLE EXTERIOR SLING	ADAPTABLE CVC STATION GENERIC MULTIFUNCTION ENVIRONMENTAL CAPABILITY	FULL BODY SLING STOWAGE INTERIOR/EXTERIOR USE
SUSPENSION	WEBBING ROPE BUNGEES WIRE	ADJUSTABLE EASILY STOWED QUICK DISCONNECT OPEN HOOK ENDS	WEBBING WITH ADJUSTABLE BUCKLES AND HOOK ENDS
STOWAGE	ROLLING	SMALLEST VOLUME	SUSPENSION MEMBERS ATTACHED TO SLING ROLLED OR FOLDED BUNGEE RESTRAINT

overhead and bulkheads to provide near-horizontal or off-vertical angular attitudes for resting, depending on the available space. The Sling-Harness gives support to the body and partial enclosure for a degree of isolation. It has these features:

- Screen fabric netting as the basic structure providing for air circulation and some see-through visibility
- Diagonal load distribution webbing
- Trapezoidal shape
- Universal attachments for assembly with Modular Pads and tensioning straps
- Light weight
- Ease of stowage
- Low cost

The final design matches the elasticity of the reinforcing webbing with the stretch of the open-weave netting so strength is achieved without dominant stress lines. Several attachment provisions are included to provide less than full deployment modes and means for potential stowage provisions.

Figures 5-4 through 5-7 illustrate the Sling-Harness in various full-size vehicle interior locations:

The resultant Sling-Harness is extremely light, folds or rolls into a very compact package and has multifunction configurations for use. Figure 5-8 illustrates the small size of the folded Sling-Harness.

5.6.2. Modular Pad. Modular pads were identified early as a hardware item that must be supplied to the individual crewman simply for comfort in extended periods of vehicle occupancy. They should lend themselves to cushioning the crewman's head and body against uncomfortable objects and give support to the head and neck areas.

A survey of commercially available cushions that might be available for the CVC situations was conducted. These cushions are primarily for recreational purposes such as boat cushions, stadium seating, backpacker's ground pads, and so

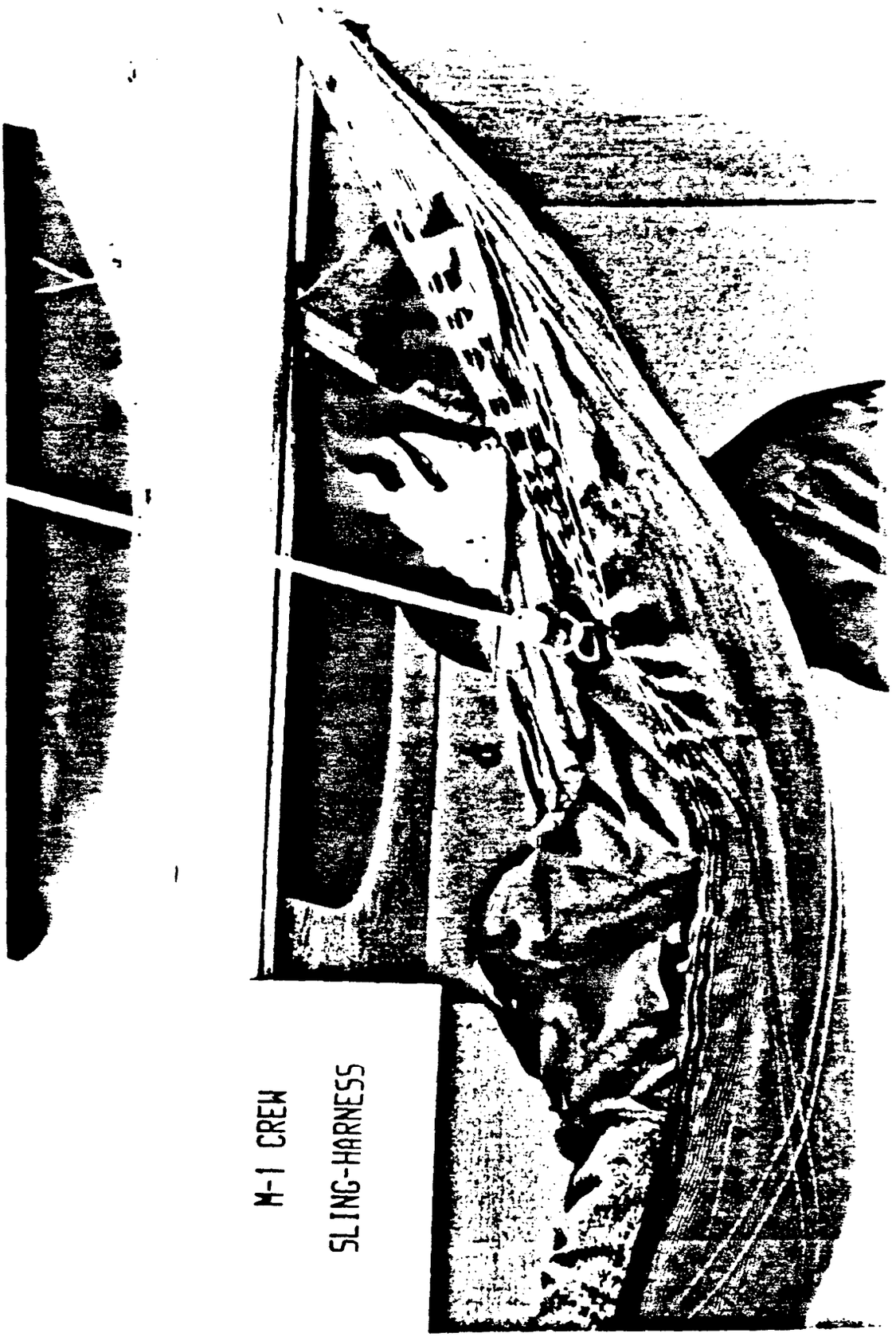

Figure 5-4. Sling-Harness Installation, M-1 Turret

Figure 5-5. Sling-Harness Installation, M-1 Turret

Figure 5-6. Sling-Harness Installation, M-1 Loader Station

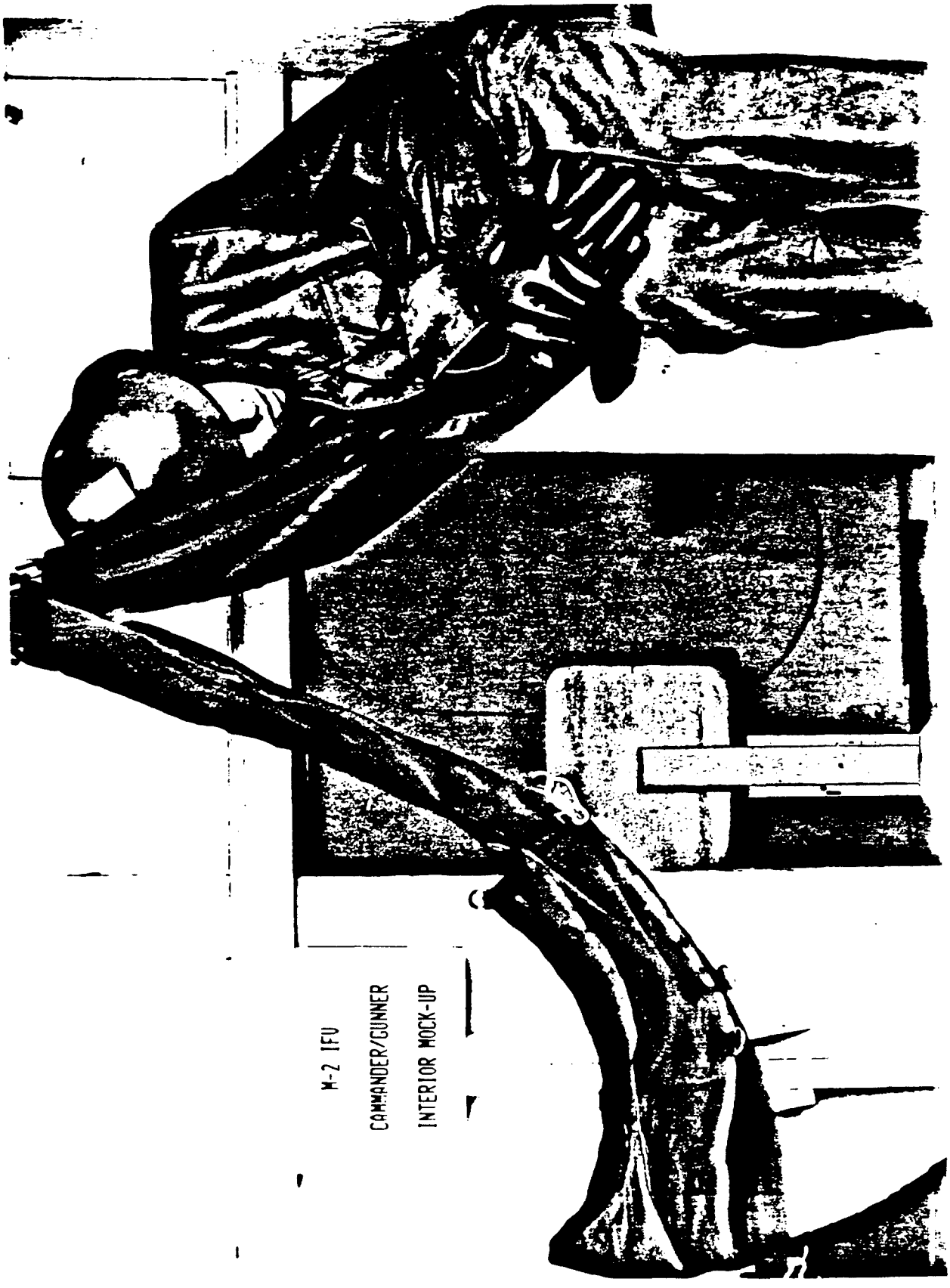

Figure 5-7. Sling-Harness Installation, M-2 Commander and Gunner

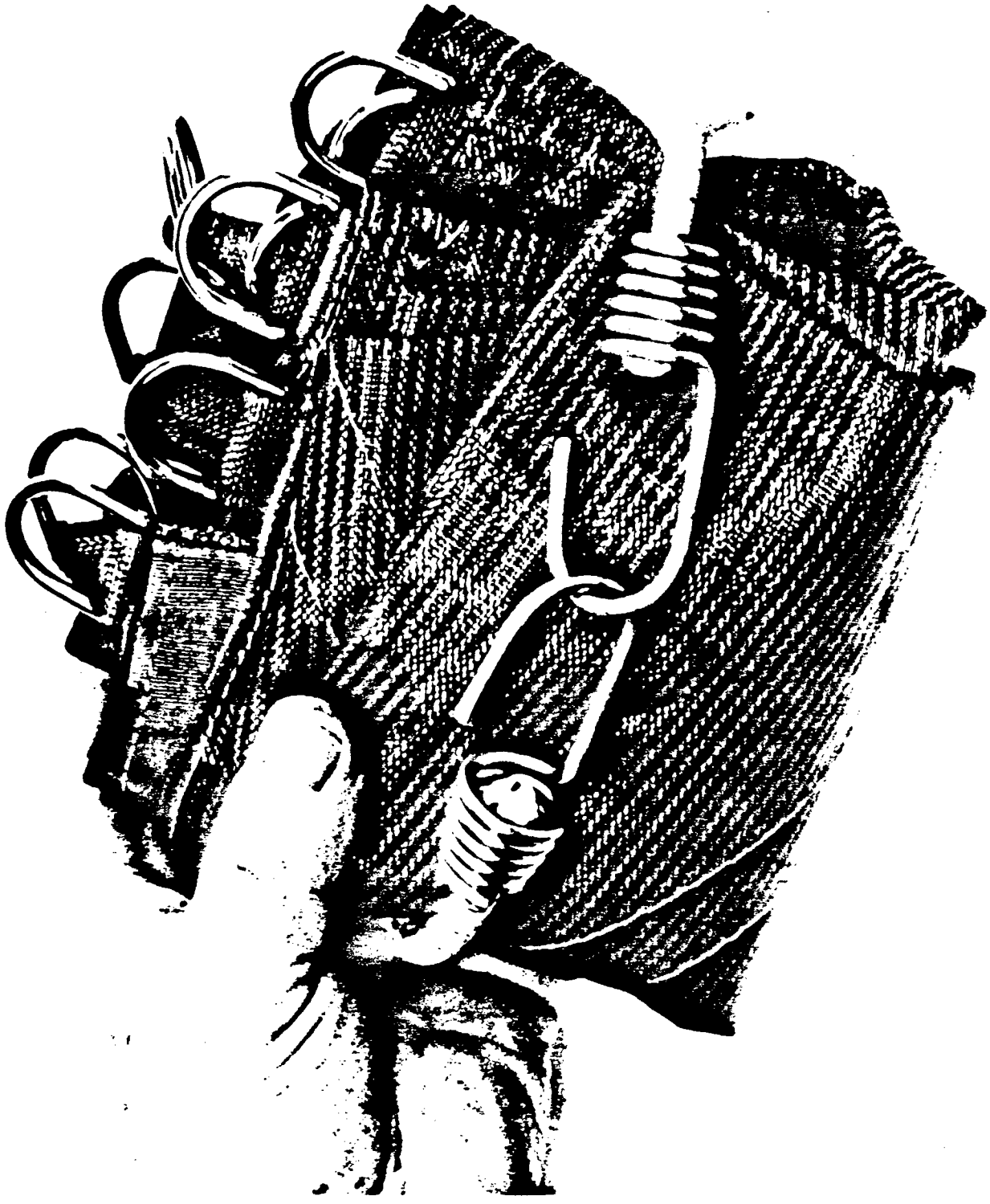

Figure 5-8. Sling-Harness, Folded

forth. None was deemed satisfactory because they did not meet the following requirements:

- Ability to be fastened together by a gloved and blindfolded man
- Structural capability for body suspension under vehicle dynamic loading (1.5 x gravity)
- Ability to withstand potential contamination and/or absorption of contaminated substances
- Capability to be folded for stowage

INVOTEC prepared a requirements document, Figure 5-9, and solicited prototypes from 10 cushion manufacturers. Two prototypes were received and evaluated in the vehicle interior mockup. The following problems were uncovered:

- Some means other than cushioning alone is required to distribute the body load
- Pads should be symmetrical, top/bottom as well as at all edges
- Attachment fittings should be capable of withstanding maximum structural loads
- Consideration must be given to the thermal properties of the materials over the probable temperature range of use (assumed to be -45 to +130 degrees F (one foam candidate became rigid at +40 degrees F in cold testing)
- The size, shape and thickness of the pad must be compatible for folding and stowage

Size of the pad should not exceed the largest seat bottom, 15 by 15 inches in the M2 IFV and 15 by 17 inches in the M1A1. At the minimum it appears that 8 inches is the limit of usefulness. Thickness greater than one inch restricts folding without additional benefit in cushioning. Shapes other than square must be considered. For example, in using a Modular Pad as an auxiliary seat for the tank commander in open-hatch operations, a rectangular shape or rectangular shape with triangular ends may be desirable.

In the use of the Modular Pad as part of the exercise device, a rectangular pad would be preferred. In many cases at the seating stations in the vehicle, the particular conformation

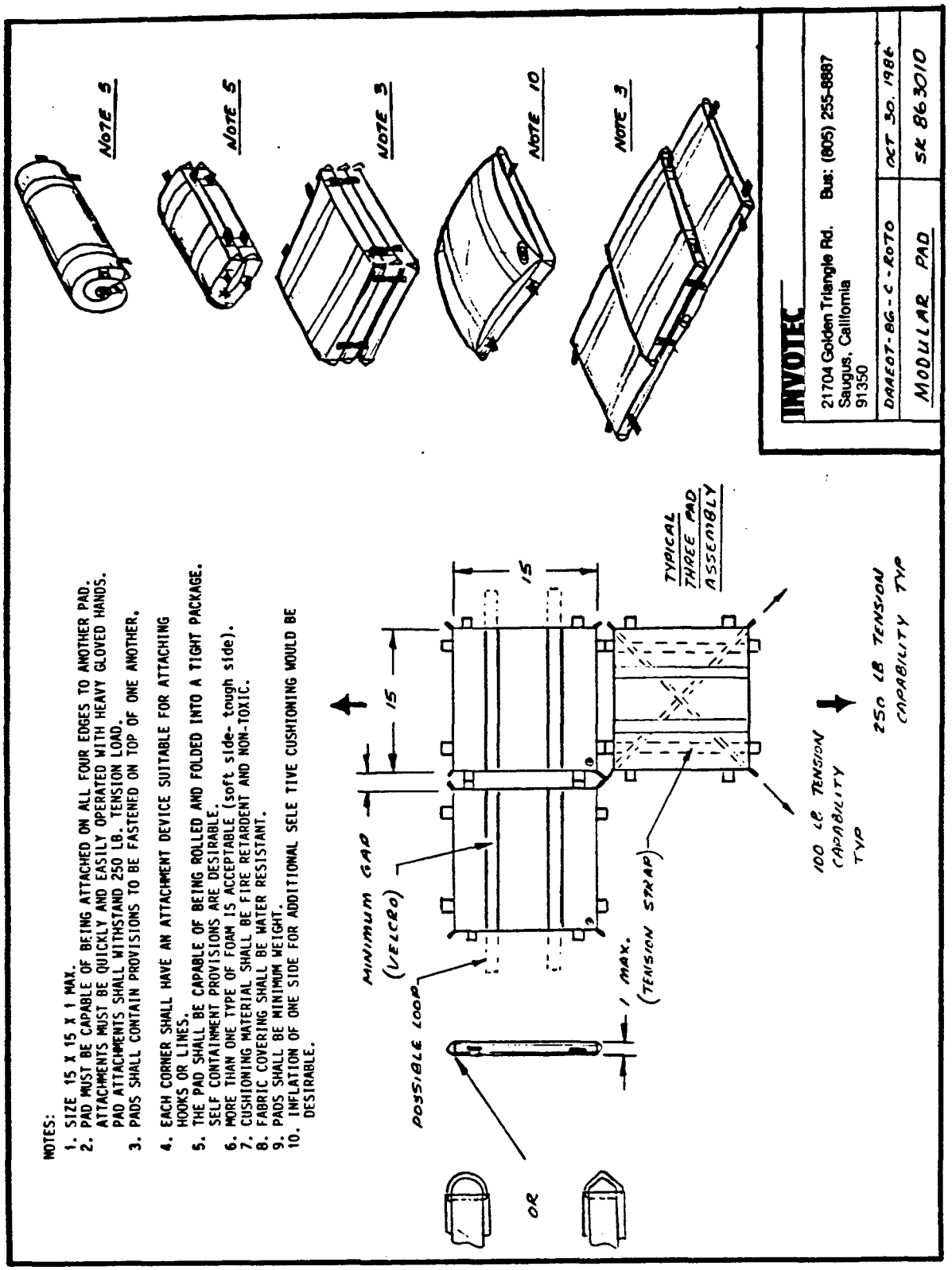

Figure 5-9. Modular Pad Concept Requirements

of wall or equipment may best be cushioned by a rectangular shape. The conclusion is that if a square shape is adopted as the standard to match seating for example, it should also be foldable into a rectangular shape.

Table 5-3 is a matrix of Modular Pad design considerations.

INVOTEC procured samples of cushioning, covering, attachments, foundation materials, and conducted an evaluation of various designs for the CVC application. Candidate attachments, suspension members are illustrated in Figure 5-10. A sample of candidate concepts showing variations in construction is illustrated in Figure 5-11.

Features of the selected design concept include:

- Central load distribution foundation
- Symmetrical, non-loadbearing cushioning attached to each side of the foundation
- Impermeable coating over cushioning surfaces
- One-piece, universal attachment fittings at each corner and side
- Foldable in one direction
- Top and/or bottom surface means for self-attachment to other pads and Sling-Harness.

The load distribution foundation consists of a single layer of coated fabric for the load distribution element. Several candidate materials are available for this foundation:

FABRIC	COATINGS
Polyester	Vinyl
Dacron	Neoprene
Nylon	Urethane

Cushioning material candidates are closed-cell foam, latex rubber or expanded cross-linked polyethylene. The cushioning is applied to both sides of the strong-back foundation, providing a symmetrical pad with loading on the foundation and not on the cushioning.

Attachments are located at each corner and the center of each side. This allows hooking the pads together in any geometrical configuration.

Table 5-3. Modular Pad Design Considerations

PAD ELEMENT	ITEMS/MATERIALS CONSIDERED	DESIRABLE CHARACTERISTICS	CONCEPT SELECTED
CUSHIONING	POLYURETHANE OPEN CELL CLOSED CELL POLYPROPYLENE OPEN CELL CLOSED CELL LATEX RUBBER NATURAL RUBBER CONFORM (Proprietary)	LIGHTWEIGHT NONHYGROSCOPIC SEMIRIGID RESILIENT DURABLE NONTOXIC NONFLAMABLE ENVIRONMENTAL CAPABILITY LOW COST	CLOSED CELL POLYPROPYLENE Same material as existing Army issue individual ground sleeping pads
COVERING	NYLON COATED NYLON DACRON COATED DACRON KEVLAR COATINGS NEOPRENE URETHANE PVC	NONABSORBENT TOUGH STABLE TENSILE AND TEAR RESISTANT LOW ELASTICITY SOLVENT RESISTANT LOW COST NON-FLAMMABLE	COATED FABRIC Coating on interior
ATTACHMENTS	SNAPS VELCRO BUCKLES BRUMMEL HOOKS CLASPS QUICK RELEASE SNAPS PELICAN HOOKS SHACKLES CAM HOOKS	GLOVED OPERABLE BLINDFOLD OPERABLE SIMPLE RESISTANT TO CORROSSION ENGAGEMENT SURITY UNIVERSAL APPLICATION INTERCHANGEABLE ADJUSTABLE QUICK OPERATION	INVOTEC DESIGN UNIVERSAL CLIP Single part
TENSIONING MEMBERS	ELASTIC CORD ROPE WEBBING	MINIMAL STRETCH GLOVED OPERATION COMPATIBLE WITH VEHICLE ADJUSTIBLE UNIVERSAL APPLICATION	WEBBING More universally fits around vehicle structures
LOAD DISTRIBUTION	FABRIC WEBBING CENTRAL FOUNDATION NETTING ENDS CORNERS MID-POINTS	SINGLE PIECE LOAD DISTRIBUTION MINIMAL STRETCH COMPATIBLE STABLE	SINGLE FOUNDATION Symmetrical loading
FOLDABILITY/STOWABILITY	ROLLING FOLDING (ONCE) FOLDING (TWICE) SEPARABLE PADS INFLATEABLE SELF INFLATING	FLEXIBILITY FOLDABILITY STABLE SMALL SIZE SELFCONTAINED	SINGLE LOGITUDINAL FOLD Good optional shape and size

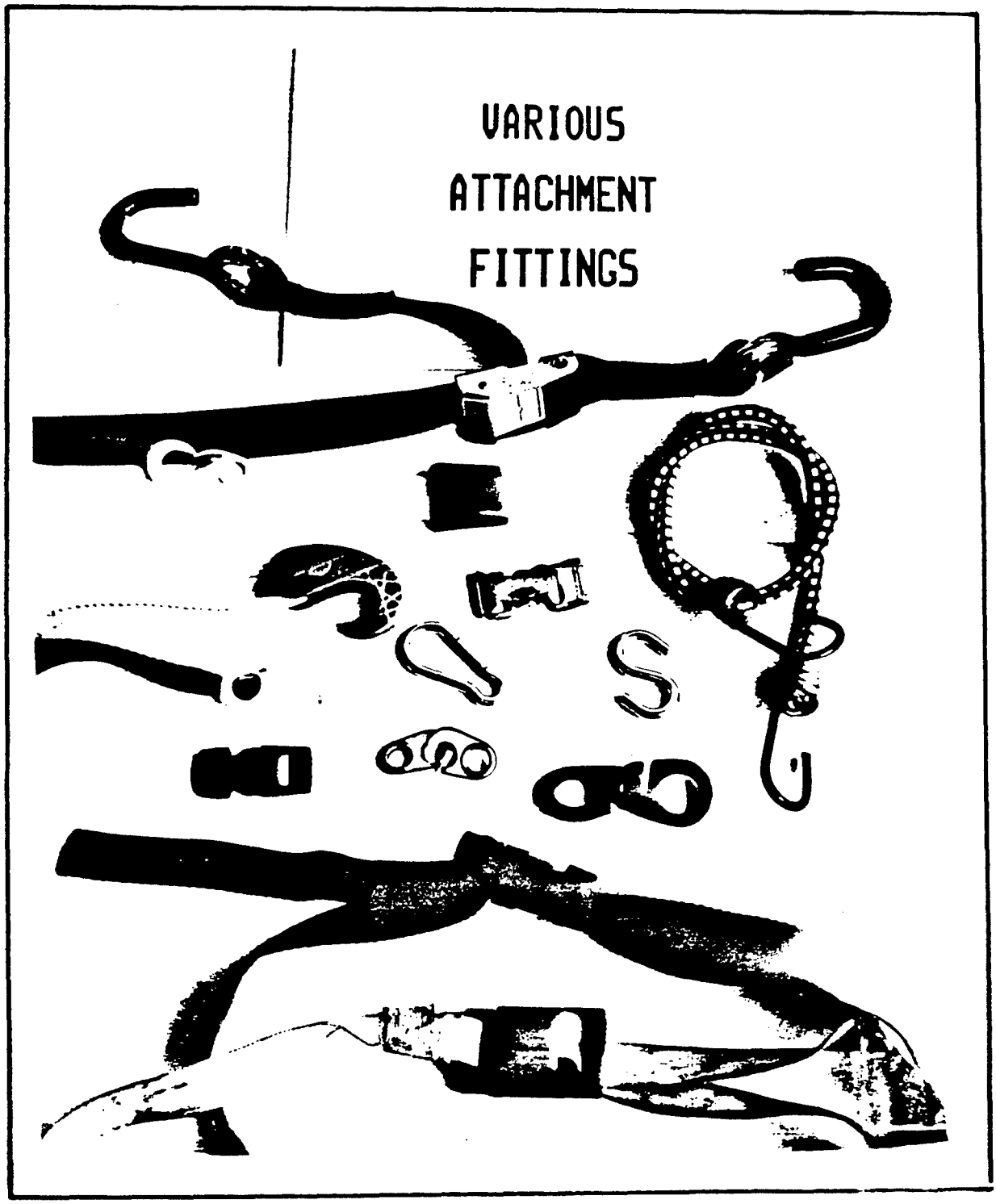

Figure 5-10. Various Attachment Fittings

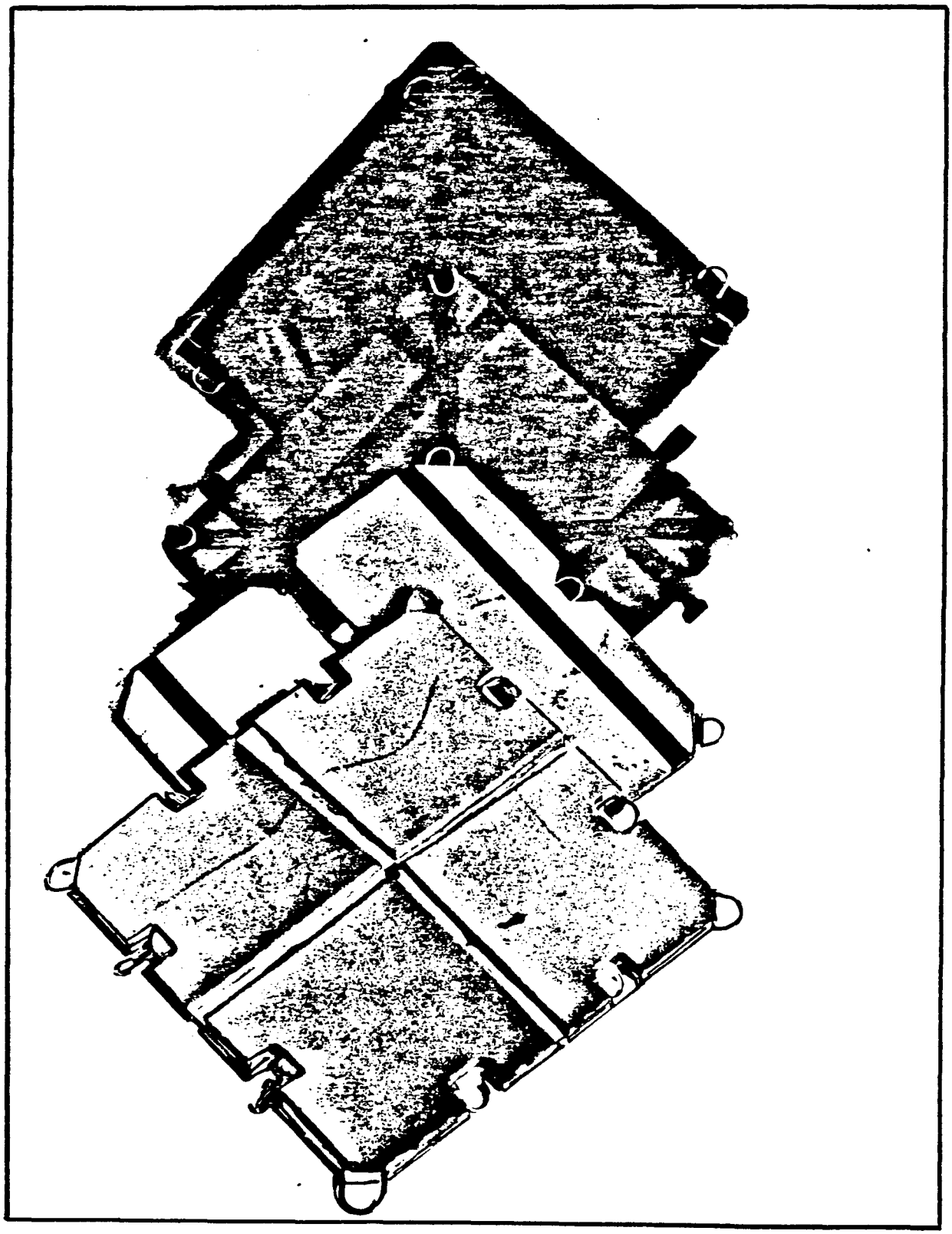

Figure 5-11. Modular Pad Concept Prototypes

A number of commercial fasteners were evaluated. The criterion for gloved, blindfolded operation eliminated most of these candidates. INVOTEC designed a new, one-piece fastener which can be used at all attachment points, is compatible with round or flat suspension lines and can be removed for repair or replacement. Figure 5-12 shows the fastener configuration and manner of engagement with another fastener.

The pad assembly will be covered with a coating of vinyl or other synthetic material to provide an impermeable surface which will resist contamination and can be easily cleaned. A crease between the cushioning pads allows longitudinal folding for stowage or doubling of the cushioning.

Two hook and loop strips (Velcro) will be attached to each side.

These strips hold the pad together in the folded position, hold one pad to another in a stacked formation and hold single pads to the Sling-Harness.

Figure 5-13 shows the proposed pad configuration. Figure 5-14 shows a multiple pad assembly. A full-size model of this concept (15 by 15 inch) was fabricated and tested, demonstrating the capability to satisfy the design criteria outlined above.

The Modular Pad with slings and two support bars can be fitted to the tank commander's hatch to serve as a head-out seat for open-hatch operations. Figure 5-15 shows three modular pads in use as a sling-seat for head-out operation by the tank commander. In this use three pads are assembled together and slung from the commander's hatch using two adjustable bars.

Another version would use one folded pad, suspended by a single suspension strap on each side, hooked to the vehicle structure.

5.6.3. Extendable/Adjustable Bar. The extendable and adjustable bar serves several functions:

- Modular Pad suspension (open-hatch seat)
- Sling-Harness suspension and end forming strongback
- Exercise device

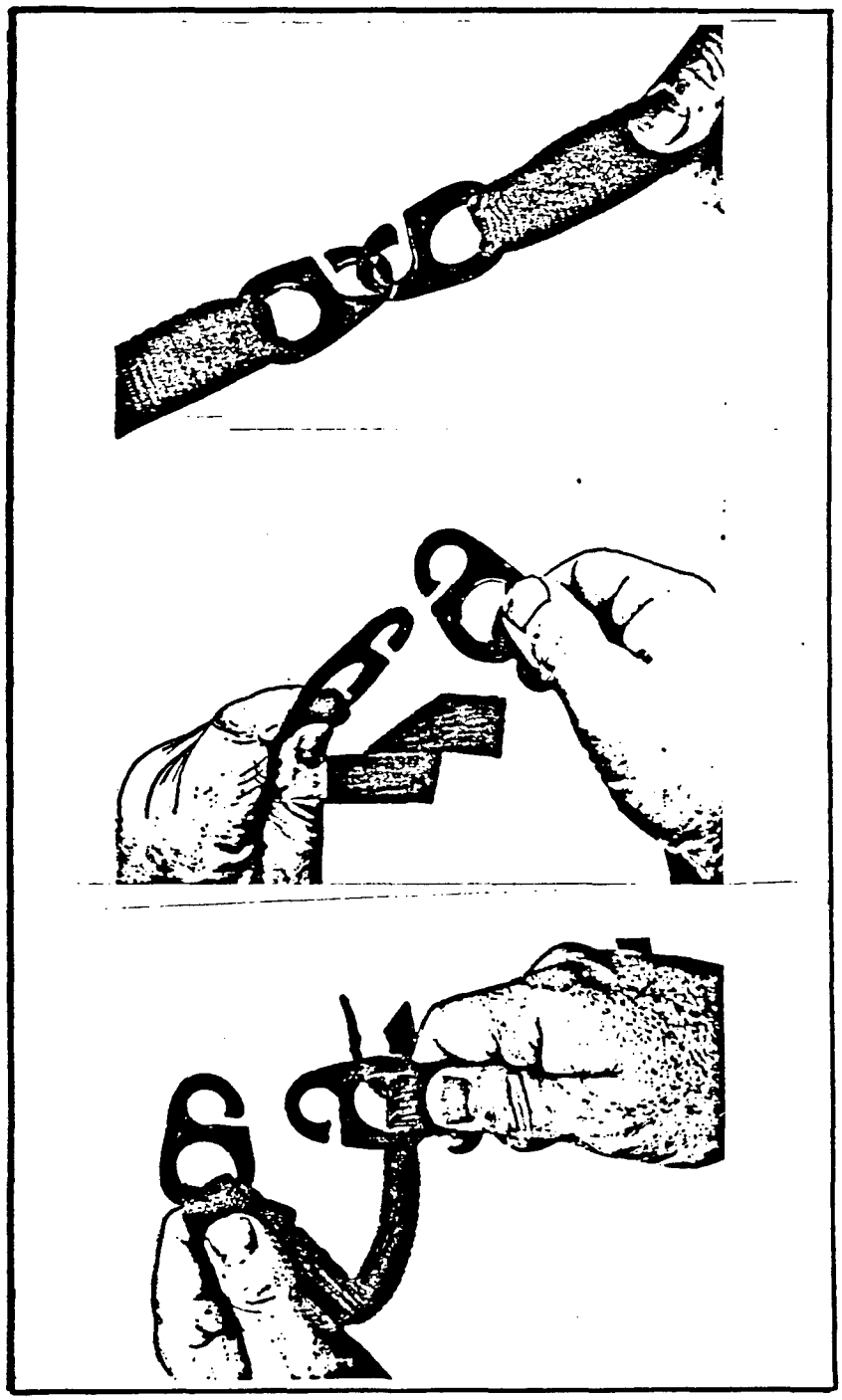

Figure 5-12. INVOTEC-Designed One-Piece Fitting

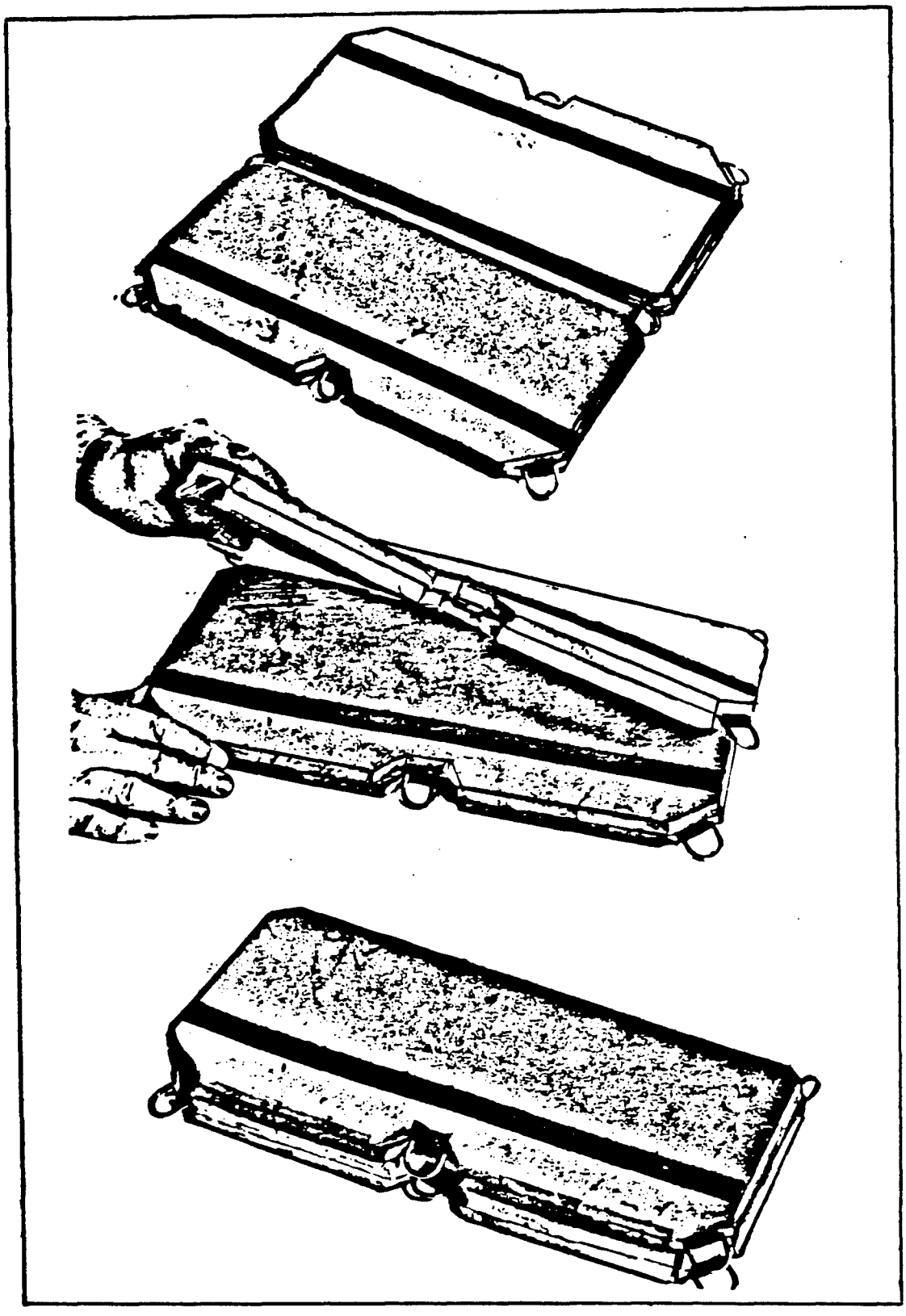

Figure 5-13. Modular Pad, Folding

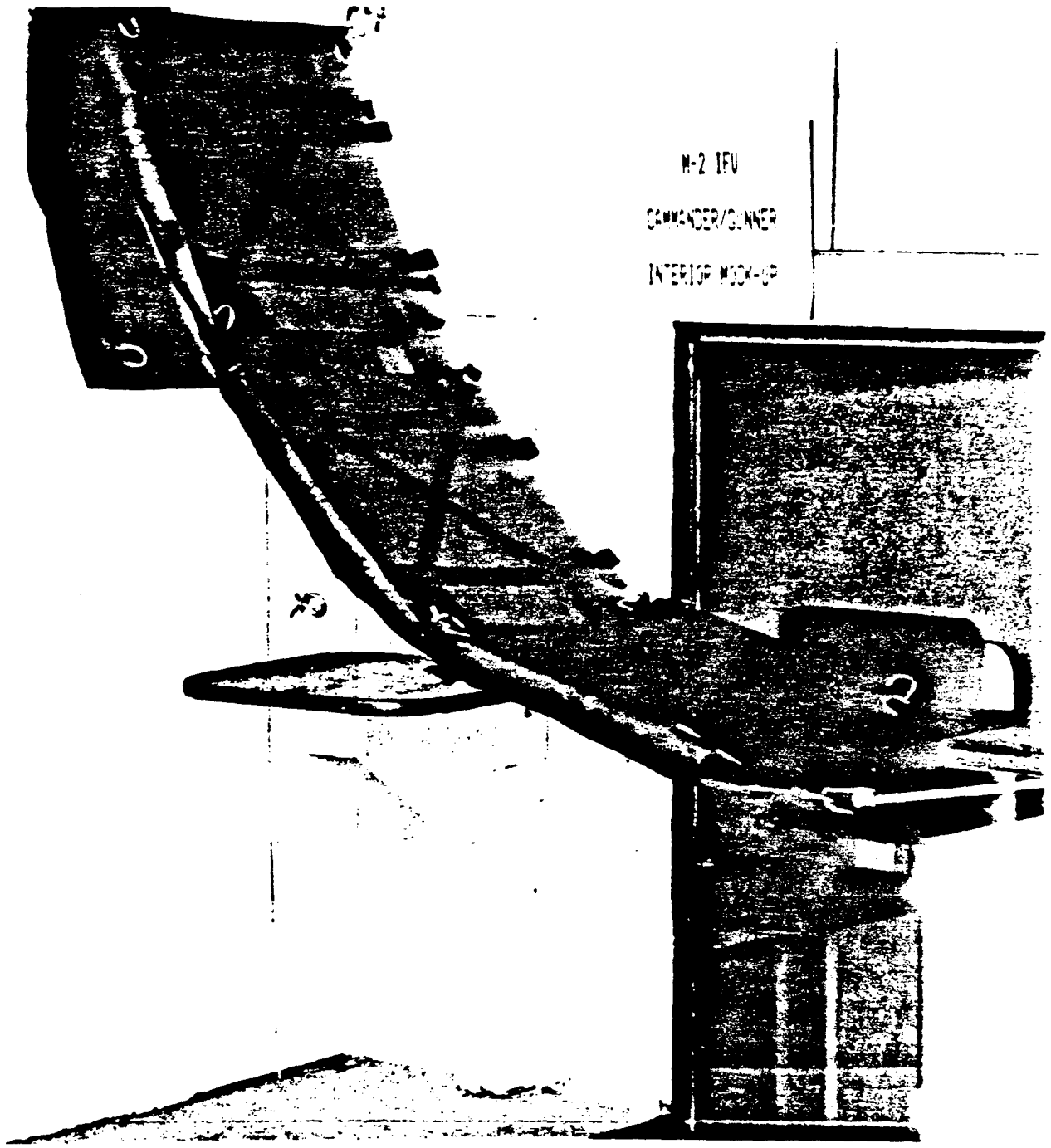

Figure 5-14. Modular Pad, Multiple Pad Assembly

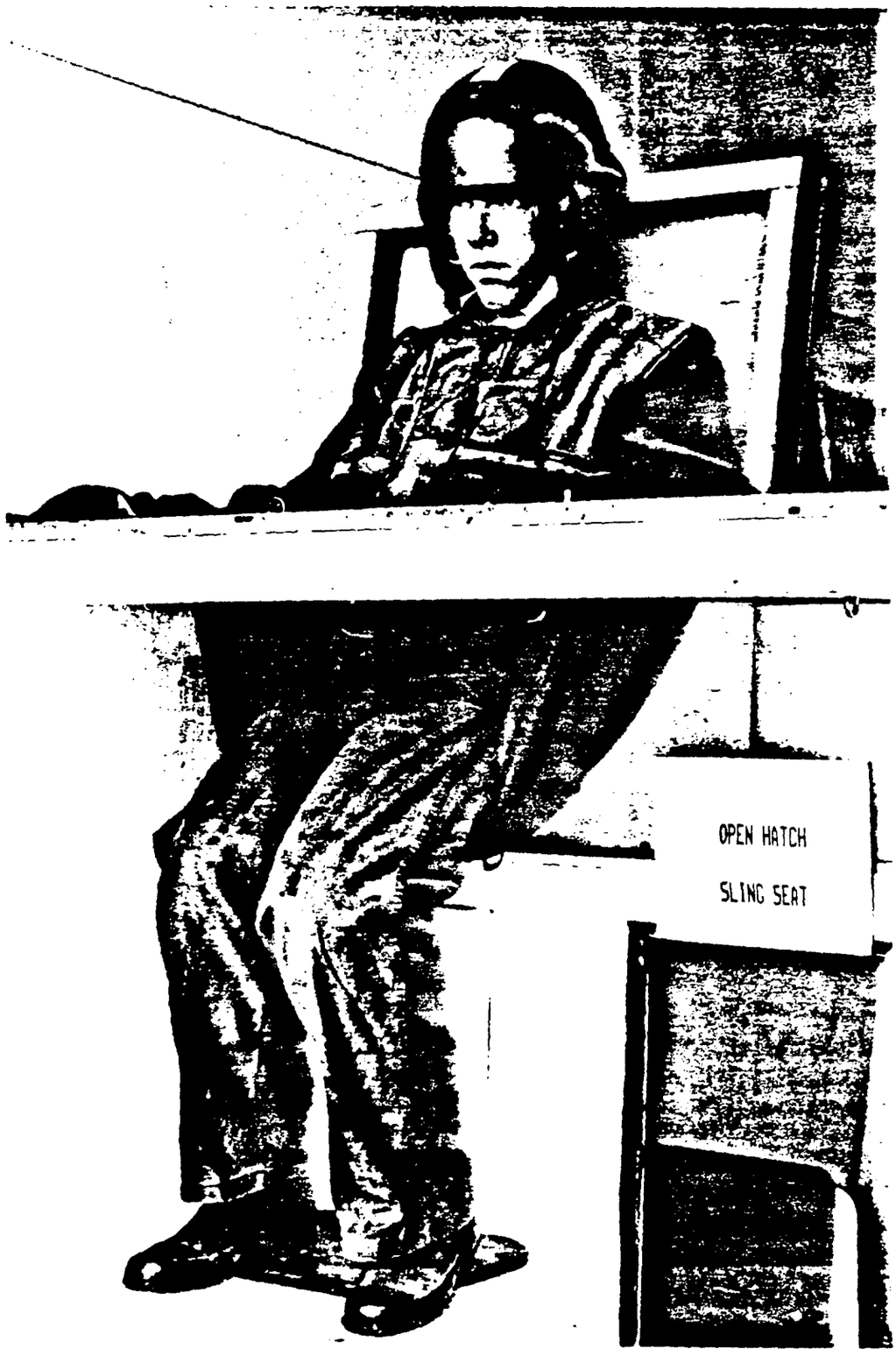

Figure 5-15. Modular Pad Open Hatch Seat

The extendable bar is illustrated in Figure 5-16. The bar consists of two concentric tubes of different diameters. One tube slides inside the other. The bar is infinitely adjustable at any selected point between 18 and 32 inches. A twist-lock mechanism is engaged by holding one tube and twisting the other.

At the end of each tube is a fitting which provides an attachment point and a retainer for three additional attachment devices which can slide along the bar.

It is proposed that the bars be of a lightweight material such as aluminum or reinforced fiberglass. The stiffness and strength of the bar will be sufficient to support a 400-pound load as a simple beam.

5.6.4. Exercise Device. The exerciser is assembled from the extendable and adjustable bar, available Bungee restraint cords, hardware of the Sling-Harness, and/or a rolled-up Modular Pad in various combinations. The exerciser can be used in the various configurations (as conceived by the crewman) to provide an elastic exercise capability concentrating on different muscle groups. Used with a folded or rolled Modular Pad, the stretch can be against the individual's back, shoulders, legs, etc.

Experience in exercising in confined spaces was found at NASA/Johnson Spaceflight Center. The Gemini astronauts had an in-flight exerciser which provided 70-pounds force at 12 inches of stretch. Gemini crews exercised with this device three times a day for isometric/isotonic stimulus and used the device at other times in testing to record biomedical data. The Gemini device was a single Bungee attached to two parallel bars.

A special exercise device is not required for the CVC application since a satisfactory one very similar to the Gemini device can be assembled from available components in the CVC sleep/rest kit.

The only two components required are: (1) one or two extendable bars used in conjunction with a Modular Pad pad or Sling-Harness, and, (2) one or more elastic cords with end hooks as now used for cargo restraint on the vehicle. Various exercise formats for the use of this combination are illustrated in Figure 5-17.

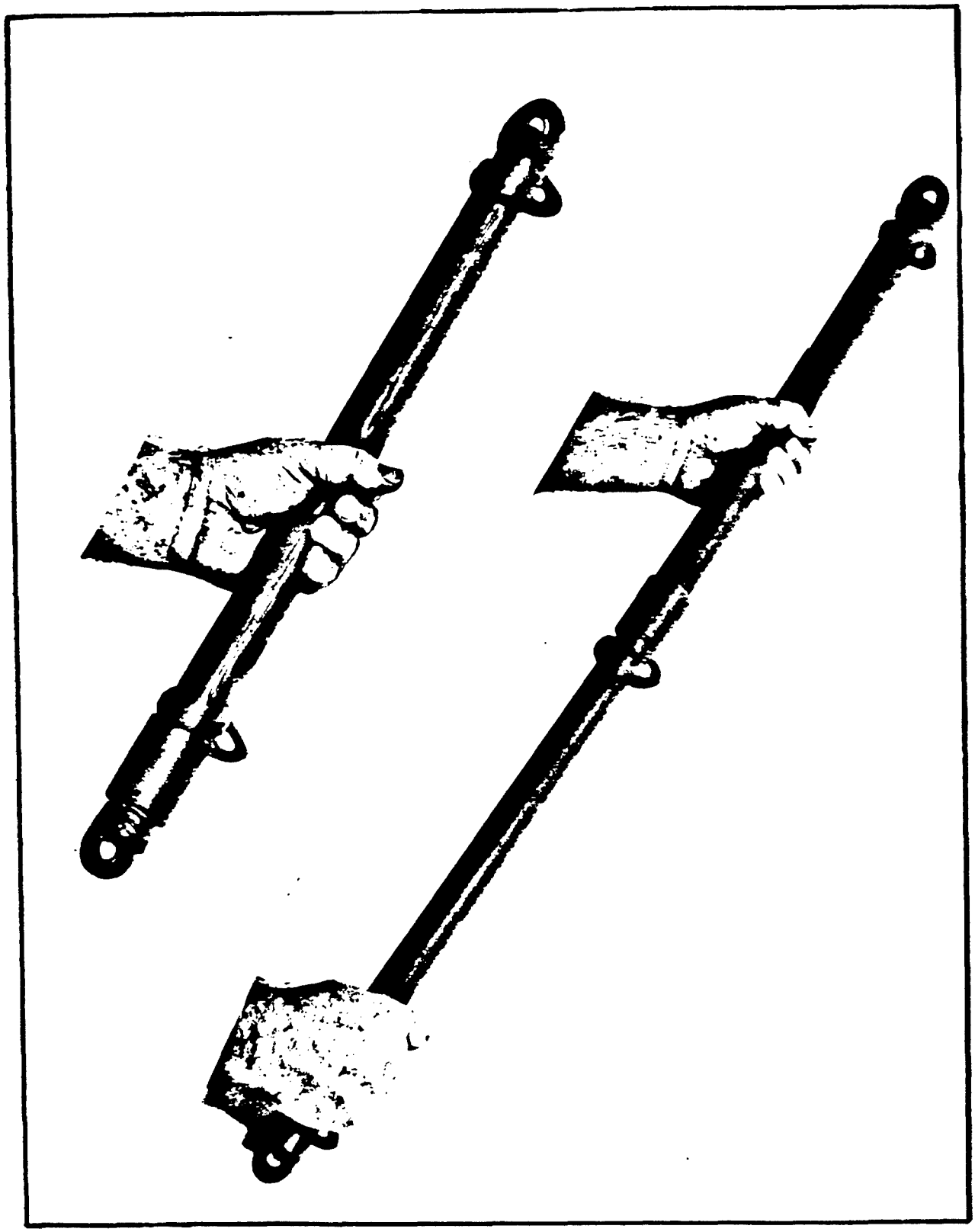

Figure 5-16. Extendable Bar

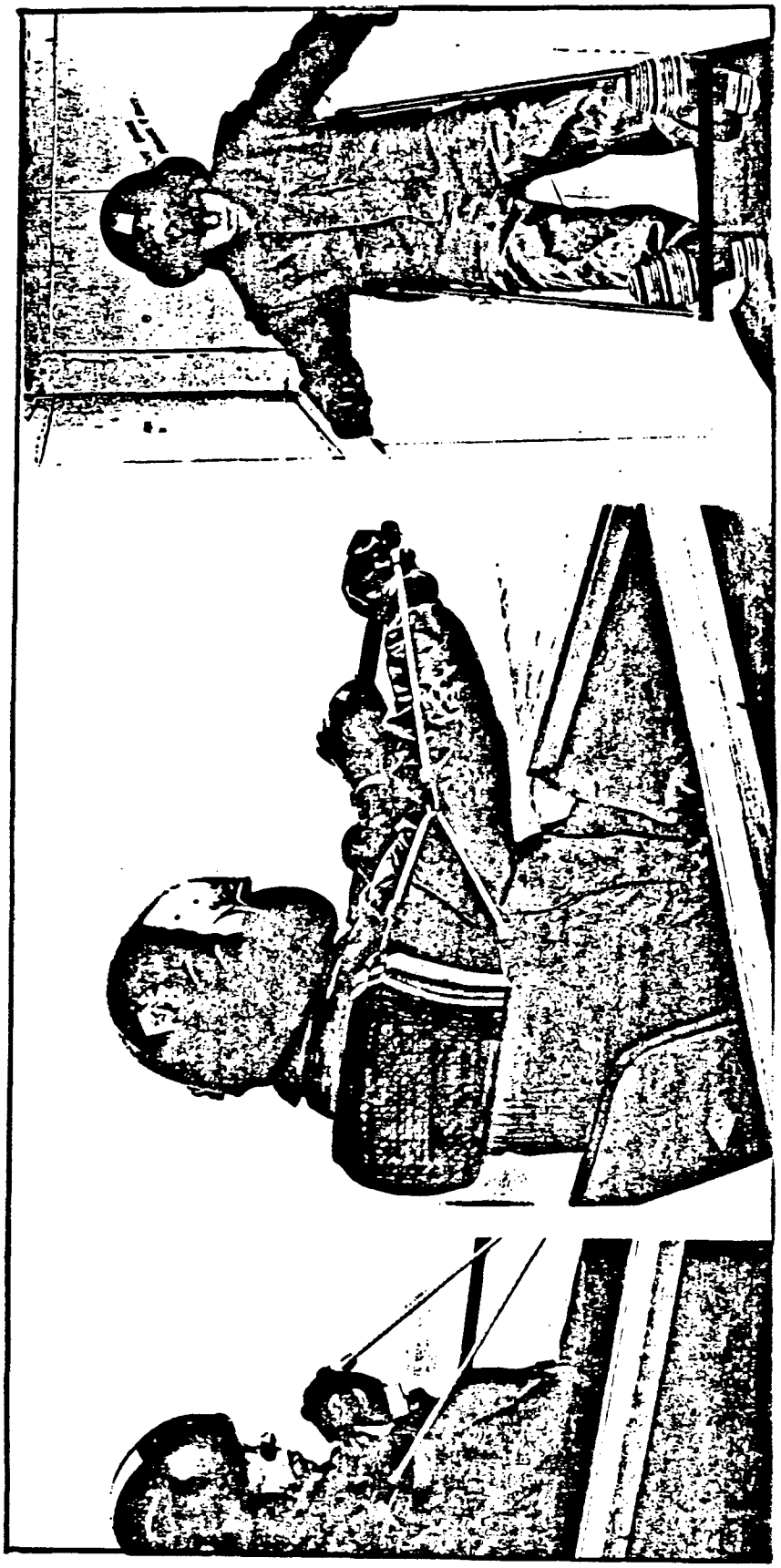

Figure 5-17. Exercise Formats

5.6.5. Massage Device. This is an electrical vibrator, drawing on dry-cell batteries or vehicle power. It is used alone or in connection with several configurations of the Modular Pad for relaxing massage to tight muscles and stimulation of blood circulation. INVOTEC studied various commercial massage devices, most which are more complicated than necessary. A very simple, and small, eccentric or solenoid is adequate and exhibits a reasonable duty cycle with available dry cells.

5.6.6. Cassette Tapes and Player. INVOTEC identified the need for audio cassette tape programs that can be adapted into the CVC headset or networked into the vehicle's intercom system.

A cassette player can easily be made compatible/adaptable to the vehicle's intercom network. Two interfaces are anticipated:

- A connector/adapter at the plug (U-174/U or similar) allowing the cassette player to be connected directly to one individual's CVC helmet headset outside of and detached from the vehicle intercom, providing the individual free and sole use of the cassette

- Connector/adapter at the tank commander's intercom control box, allowing him, at his option, to interconnect the cassette player into the intercom system to all stations in the vehicle

As a minimum, the cassette tape should contain three programs:

- Self-teaching guided program for exercise and muscle relaxation. This program should be fast-paced, interesting, relevant to the CVC situation and contain motivational, performance-related and morale-building messages

- Self-suggested, sleep-inducing imagery and conditioning

- Personally selected audio relaxing aids, (music, white noise, etc.)

5.7. Data Collection and Analysis

5.7.1. Data Base Search. A literature search was made through the DIALOG computerized data base using a computer with modem connection and special DIALOG software. The search was made using the following key words:

- Combat vehicle(s)
- Tank
- Crew
- Fatigue
- Work, rest, work/rest cycle(s)/factors
- Sleep, Sleep deprivation

Time of interest was set to identify recent reports of the years 1980-1986. First search was made of the information ("411") file which identifies those data bases having the chosen key words in titles and/or abstracts. Search was made for key words alone, then key words occurring in combination with other key words, adjacent to each other within one word. Thirty data bases were identified by the information inquiry and 34 documents were identified within these as potentially useful based on review of their abstracts presented on screen. INVOTEC obtained a total of 11 documents of probable use. Of the 11 obtained, 5 documents were of excellent applicability and are outlined in paragraph 5.7.2. below.

At NASA/Ames Research Center Library physical search was made through the STAR collection, with dates of interest from the years 1960-1986 in order to recover Mercury, Gemini and Apollo spacecraft sleep/rest experience.

5.7.2. Defense Technical Information Center (DTIC). INVOTEC used DTIC resources for a search of reports on file relating to combat vehicle crew resting/sleeping, human factors in combat vehicle crew performance and the work of U. S. Army R&D activities in testing and evaluating combat vehicle crew operations and capabilities while enclosed in vehicles with the hatches closed for extended periods under simulated combat conditions.

A bibliography was received and selected documents were obtained from Information on Demand, Inc., P.O. Box 9550, Berkeley, California 94709 (415) 644-4500/(800) 227-0750/Cable: INFODEMAND.

The following documents are felt to be relevant and useful in the CVC sleep problem:

5.7.2.1. Goldman, Ralph F., Ph.D. and Staff, "Microclimate Cooling for Combat Vehicle Crewmen," U. S. Army Research Institute of Environmental Medicine , Natick, MA 01760, 18 June 1982.

- Crews dressed in full NBC protective ensemble, (MOPP-4) while enclosed inside combat vehicles with temperature 80 to 95 degrees F, suffered heat stress producing early performance decrement and subjective inability to continue operations

- Some form of cooling of the individual is needed to permit sustained operations under heat stress

- Four methods of individual cooling were noted:

  - water cooled undergarment
  - air cooled vest
  - ice pack vest
  - wettable cover

5.7.2.2. FM 90-3, "Desert Warfare," HQ Department of the Army (1979) indicates that drinking water requirements for NBC-suited CVC under buttoned-up conditions may exceed the existing interior reservoir capacity. FM 90-3 indicates that 7-11 quarts of water per day per man will be required in desert operations. For a crew of four, this is 28-44 quarts or 7-11 gallons. The current interior container for the M1 tank holds 3 gallons.

Inspection of the M2A1 model IFV's shows the water reservoir has been changed from a single conformal tank of 10 gallons to two standard 5-gallon flip-top water cans. The standard cans have been installed without provision for spigots so they must be removed from the stowed position and poured into the canteen or canteen cup for drinking. Spillage is possible. With 9 men in the M2 IFV, in desert operations a minimum of 8 quarts per man per day is required. The existing 10-gallon reservoir provides sufficient water for a daily ration for 5 men only. With a 9-man complement the M2 IFV needs 18 gallons per day or 54 gallons for three days

buttoned-up. Fresh water is necessary for re-hydration and health as well as comfort. Water availability affects the ability to sleep.

5.7.2.3. Toner, Michael M. et al: Report No. T2/83, "Comparison of Air Shower and Vest Auxiliary Cooling During Simulated Tank Operations in the Heat," U. S. Army Institute of Environmental Medicine, Natick, Massachusetts, April 1983.

This report documents the results of a tests of air shower and vest auxiliary cooling worn by two tank crews dressed in CVC clothing and chemical protective clothing, while enclosed in the M1E1 Main Battle Tank. The tests showed that vest auxiliary cooling is more effective for crewman cooling than air shower.

5.7.2.4. Earl, William K. Research Product 84-05, "Human Factors Engineering Design Criteria for Future Systems, Report No. 1: Tank Design Criteria Evolving from the M1 Tank Operational Test III," U. S. Army Research Institute for the Behavioral and Social Sciences, 5001 Eisenhower Avenue, Alexandria, Virginia 22333, March 1984.

- A number of deficiencies in human factors in the tank were cited as needing improvement, such as commander's seat which is not adjustable for open-hatch operation and instant stowage when hazardous conditions occur, inadequate back support for the driver's seat, etc.

- No evaluation was made as to suitability of the space and seats for enclosed operations and sleeping/resting inside the vehicle.

- Stowage space is inadequate for personal equipment items such as: CVC helmet, NBC gear, etc., and no provision is made for sleep gear.

- No consideration was given to long-term enclosed operations and habitation under enclosed conditions on NBC threat.

5.7.2.5. Research Note 85-68, "Soldier Performance in Continuous Operations," published by the Training Research Laboratory of the U. S. Army Research Institute for the Behavioral and Social Sciences, 5001 Eisenhower Avenue, Alexandria, Virginia 2233-5600. (Government Accession No. AD-8160471).

5.7.2.6. Research Note 85-69, "Soldier Performance in Continuous Operations: Administrative Manual for a Briefing and Seminar for Command and Staff Personnel," published by the Training Research Laboratory of the U. S. Army Research Institute for the Behavioral and Social Sciences, 5001 Eisenhower Avenue, Alexandria, Virginia 2233-5600. (Government Accession No. AD-8160471).

5.7.2.7. Research Note 85-70, "Soldier Performance in Continuous Operations: Administrative Manual for a Briefing and Seminar for Platoon and Squad Personnel," published by the Training Research Laboratory of the U. S. Army Research Institute for the Behavioral and Social Sciences, 5001 Eisenhower Avenue, Alexandria, Virginia 2233-5600. (Government Accession No. AD-A160278).

These documents provide detailed insights into the problems of sleep deprivation, sleep discipline and work/rest cycles on the combat effectiveness of leaders and combat personnel. The documents give the following information useful in CVC sleeping/resting under confined conditions:

- Work/rest sleep discipline and plans are important in sustained operations

- The general priorities for sleep/rest are:

  - Leadership
  - Evaluations, judgements and calculations
  - Vigilance tasks
  - Other activities

- Sleep for leaders is by far the most critical factor owing to the high sensitivity of decision making and other cognitive tasks to fatigue. (Figure 5-1 shows the differences in degradation with sleep deprivation by job category.)

- Cat napping at every opportunity and even for the most brief periods is the technique of greatest promise for holding down the effects of lost sleep. Effective cat-napping requires that the soldier fall asleep as quickly as possible and that he become awake and be alert just as quickly when he is again needed.

- Falling asleep quickly and awakening quickly are skills that can be learned with practice.

- Stress control is important in resting, sleeping and relaxation. Techniques which can

help the soldier gain control over stress are:

  - Relaxation techniques--calming the mind and body

  - Self-suggestion--relaxation, warmth, imagery and activation

  - Meditation--relaxation, self-suggestion breathing and physical exercises

  - Inoculation--mental conditioning by thinking about possible stressful situations and imagining solutions

- Moderate exercise, especially of large muscles of the body helps to increase alertness and help sustain combat effectiveness

5.7.3. Interviews. In an interview with Mr. Mike Golden, Human Engineering Laboratory, (HEL), Aberdeen Proving Ground, the REDLEG Demonstration (1985) was described. A volunteer crew of six artillery fire control personnel was fully confined within an enclosed simulated command post vehicle especially equipped with NBC filtration and airlock. Confinement was scheduled for 72 hours and terminated voluntarily at 54.5 hours. Upper torso slings were provided to the crew members for sleeping while seated in their station chairs.

In interviews with various U. S. Army personnel at Human Engineering Laboratory, Aberdeen Proving Ground, Maryland, and The Armor Board, Fort Knox, Kentucky the following information from the Ironman testing was obtained:

In the environmentally controlled test at Aberdeen Proving Ground in 1985, directed by Ms. Monica Glumm, soldier volunteers serving as M1A1 tank crewmen while operating buttoned-up in MOPP-4 protective ensembles were able to sustain operations for 32 hours total time out of a 72-hour planned test duration. CVC individuals were allowed to exit the vehicle and dismount for relief, medical examinations and administrative reasons related to the test. Ambient temperature was moderate and controlled to 75 degrees F external (by an environmental enclosure), with tank internal

temperatures at 84-85 degrees F. The significant findings of the APG Ironman tests were:

- Vehicle microclimate equipment is essential to operational effectiveness and long duration wearing of the NBC garment. Proper airflow to suited crewmen must be provided continuously

- Crew susceptibility to discomfort is subjective with each man having his own tolerance level of physiological and psychological stresses

- Carbon dioxide build-up and hyperventilation were identified as confinement problems, causing nausea in test subjects

- Blood pooling in abdomen and legs was a medical result of prolonged sitting without ability to move/exercise

- Ability to change body position/posture is essential satisfactory resting

- Methods/techniques of exercising in place while seated or in restricted spaces may be helpful to relaxation and sleep onset

Interviews on 18 August 1986 with Ironman I test director, Captain David Graham at The Armor Board, Fort Knox and Mr. Walter Meinshausen, Battlefield Sustainment Branch of U. S. Army School, provided the following information on the tactical scenario testing of tank units at Fort Knox in the Summer of 1985:

- Test volunteers were trained tank crewmen led by experienced tank and platoon commanders

- M60A3 and M1A1 tanks were used

- Crews were dressed in full MOPP-4 ensembles with microclimate vests (M60 tanks were specially fitted and M1A1 tanks normally equipped with microclimatization)

- Test protocol followed a tactical scenario calling for simulated enemy day/night tank attack of friendly positions on a recurring 6-hour schedule of events

- Ambient temperature was the prevailing condition of the summer of 1985 in the test area. Vehicle interiors were uncontrolled

- One crew remained operationally effective for 16 hours under enclosed conditions with microclimatizer cooling. Average duration of endurance was 7.8 hours

- Early morning (pre-dawn) was the time of maximum degradation of personnel

- The ability to endure was dependent on individual tolerance, crew determination and leadership

- The longest time of operational capability was the 16 hours of one tank crew that worked under a strong leader who communicated effectively and encouragingly with his crew

- Test volunteers were given a pre-test talk describing the test scenario and confinement problems

- During the tests, crews off-duty were allowed to listen to music from their own tape recorder

- Crews played word games and engaged in other recreational activities to pass the time

- One tank commander told amazing stories to his crew over the intercom

- Strong, innovative leadership was found to be helpful in crew coping

- Exhortation, stories, mental conditioning, positive suggestions, games, recreational distractions and other psychological distractions helped

5.7.4 Visits. INVOTEC visited the following Army agencies to collect information for the study:

5.7.4.1. National Training Center, (NTC), Fort Irwin, California. INVOTEC interviewed tank crew members and commanders of the Opposition Force training cadre. These men provided the following comments relevant to armored vehicle habitability in hot climate:

- Vehicles have no internal outlet for 24-volt power to allow use of appliances

- Armored vehicles need a device for heating the Meals Ready to Eat (MRE) ration. Because the MRE package is plastic, a container of hot

water is needed to heat the meal; lacking a metal can, the MRE cannot be heated on the engine manifold as were C-rations

- Air conditioning (central or man-pack) is essential for enclosed operations in the desert.

- Positive airflow to the individual (M25) tanker's mask is desired, particularly when the vehicle is stationary

- A urinal tube with odor-control valves and outlet extension to deposit the waste clear of the tank is needed

- Positive air flow to the M25 gas/particulate filter of the tanker's mask is needed

- Better reliability of heaters is needed since these typically do not work as designed--sometimes malfunctioning to give off carbon monoxide gas. The heater is not useful in heating the MRE, which requires a hot water bath for the plastic bag

- Stereo music is desired for entertainment during waiting periods

The attitude of the combat vehicle crews was that the lack of amenities would probably persist and that crews would typically "make do" on their own.

Existing resting and sleeping items of equipment currently in use by NTC crews include a foam pad and sleeping bag that is stowed on the turret exterior bustle equipment rack. Crews seldom sleep within the vehicle but often sleep on the vehicle turret or deck.
There is no internal room sufficient to stretch out, except for very short men. Seating is spartan and uncomfortable.

Crew fatigue is exhibited in back and leg muscle tension. Relief is obtained by the driver in stretching and leaning backward. Other tank positions do not have a lean-back capability.

A modular pad was indicated as desirable for use in resting inside the vehicle. Currently the individual's personal effects bag is used for cushioning. The cushion/pad should be small, foldable and separable into pieces that would stow readily in available irregular recesses between the hull and

turret mounted equipment. The important characteristics for the modular pad are:

- Variable shapes, i.e., seat and back torso support, horizontal laying and rollable into a tube for head and neck support
- Outer covering must be resistant to snagging and tearing, able to withstand wear and tear of abrasion with the vehicle and contacts with sharp edges; should be impervious to petroleum products and easily cleaned of these
- Accessory attachments need to be provided to allow assembly into larger pad areas, couch and hammock/sling forms.

5.7.4.2. Infantry School, Fort Benning, Georgia. The following information was provided by personnel at the Infantry School:

- The existing chemical ensemble is designed for 24 hours of protection after 30 consecutive days of wear out of the chemical environment
- The infantry soldier will wear the following equipment over the MOPP-4 ensemble:
  - Load-bearing equipment (pistol belt, and suspension harness)
  - Two 30-round ammunition pouches
  - Canteen
  - Poncho
  - Entrenching tool
  - First aid packet
- If authorized, the infantry soldier will have a sleeping pad or an air mattress; both of these are bulky
- The infantry soldier has at least 70 pounds of load on his body
- It takes 8 minutes to don the protective clothing in unrestricted space
- A MRE heating unit is under development at Natick RD&E Center

In contact with a tactical unit equipped with the M2 IFV, the following information was obtained:

- The IFV has a 9-man crew, with the 10th man's seat dropped from the vehicle dismount crew because the man had no firing port and sat facing into the vehicle interior. The lack of mission activity caused the man in this position to become nauseous from vehicle noise/vibration.

- The nine-man crew consists of:

    (1) Three-man vehicle crew (commander, gunner and driver)

    (2) Six-man dismount squad

- The M2 IFV seats are adjustable in 1-inch increments for a total of 6 inches vertically. Seat backs can be flopped down over the seat. The seat can be removed by pulling pins. This is difficult to do but could be accomplished with the vehicle closed and with a full crew.

5.7.4.3. NASA/Johnson Space Center, Houston, Texas. INVOTEC visited NASA/Johnson Space Center, Houston, Texas to obtain NASA experience with astronauts in training for, and in actual sleep in, spaceflight. On first consideration the spaceflight experience would seem relevant in that the crews are enclosed in confined space under stressful hazardous conditions for prolonged periods. Particularly, the close confinement of two men in the Gemini flights lying (or floating in gravity-less orbital flight) in contour-couch seats in a side-by-side arrangement needed exercise and sleep in confined space.

INVOTEC interviewed Ms. Frances E. Mount, Aerospace Engineer, Man-Systems Division and Dr. Patricia A. Santy, MD, Flight Medicine Clinic for information on sleeping/resting equipment and techniques. The following information was obtained:

- The Gemini spacecrew used an elastic cord exerciser in daily sessions to keep muscles stimulated

- Space Shuttle crews take nonprescription sleeping pills along at their own option

Although restricted in volume, the spacecrews were confined in vehicles specially designed as life-supporting habitats, with consideration given to sleep, waste management, air

conditioning (temperature, humidity and purity), all in a closed-cycle, integrated system. The existing military combat vehicles have none of these habitat amenities and no design thought for relaxation and comfort.

In spite of the deliberate design of spacecraft as long-term habitats, with full life-support systems far removed from the Army vehicle concepts, valuable information can be derived from the NASA spaceflight experience in the following areas:

Air Purity. The presence of carbon monoxide and carbon dioxide in breathing air needs to be minimized for reasons of mental efficiency and eventually, health. Means for detection of the levels of these contaminants may be necessary items of equipment in future vehicles.

Noise/Shock/Vibration. Environmental noise has been a problem in spacecraft--sound and light barriers are needed for sleeping in space. Particularly, structure-borne sound is difficult to eliminate, including vibrations from on-board equipment functioning, e.g., the waste management system.

Head Restraints. Astronauts have used a head restraint to prevent head bobbing during sleep.

Heat Stress. Astronauts in extra-vehicular activities (EVA) are cooled inside their space suits by a full body undergarment with a network of small diameter tubes circulating a chilled water-glycol mixture to the body locations of arms, torso and legs.

Exercise. in limited space is important physiologically and psychologically. Gemini, Apollo, Skylab and Space Shuttle crews have all been provided exercise devices. Gemini used a small elastic, Bungee-cord-type with a hand-hold bar and foot stirrups; 70-pounds of pull was required to stretch the device 12 inches. Skylab used an Exergenie and Space Shuttle has a treadmill/bicycle.

Environmental Sickness. Environmental sickness is a common problem. The first day in a microgravity environment often induces motion ("space") sickness which can affect mission success as well as make for a messy workplace. Some seats in combat vehicles induce motion sickness and some crewmen are more prone to succumb to the conditions causing nausea.

Motivation and Training. Motivation and training help in the ability to cope with the psychological and physiological

stress of confinement under hazardous conditions depends on the a number of subjective factors:

- Mental state, dedication to mission success, discipline and a host of other unmeasureable but demonstrable personal qualities are important. The ways to inspire these desirable qualities may be transferable between services.

- Crew selection, first, individual selection, then selection of members of given crews are careful NASA techniques. Ability of crewmen to cope with stressful situations is dependent on individual characteristics and the dynamics of a team of individuals able to work together willingly and in dedicated fashion.

- Another aspect of crew selection is physical size. Small-sized men occupy less volume. Selection of crewmen for small size was part of the Apollo spacecraft criteria. Selection of small men for tank crews gains living and operating space in fixed-size compartments.

- Stress management is essential in resting and sleeping. Good leadership is an important factor in coping as well as biofeedback, self-hypnosis, and other techniques.

- Fatigue, boredom and restlessness lead to degradation Techniques to help in these areas are potential topics in training and motivation.

- Sensory deprivation and isolation affect the psychology of the individual and may develop into psychotic problems. Only progressive trials in simulated environments will give pre-indication of individual problems in these areas.

- Bio-feedback awareness and training to achieve physiological control by use of relaxation, self-hypnosis, hypnosis and psychological exercises are used by NASA astronauts. Each astronaut can make his own tape of relaxation programs, music, ocean noise, bird songs, white noise, etc., as is most conducive to sleep according to his/her individual predilections.

- Pharmacological intervention (or other medical means) is a last resort of action in cases of inability of individuals to relax and sleep.

- Work/rest cycles and sleep plans are detailed schedules in spaceflight. The astronauts' days are prescribed closely, with 5 to 8 hours of the 24 available for rest. On the first and last days of an orbital mission, the lower rest period is probable due to higher work task demands. Adequate rest, particularly as the continuous operations extend beyond 24 hours is vital in avoiding mental fatigue and deterioration of judgemental faculties, as is very important in leadership situations.

5.7.4.4. FMC Corporation, San Jose, California.
INVOTEC visited FMC, San Jose for the purpose of collecting information on the interior of the M2 and M3 Bradley Fighting Vehicles. The M2 and M3 vehicles are identical in the vehicle crew positions (commander, gunner and driver).

5.7.4.5. Natick RD&E Laboratories, Natick, Massachusetts
Natick RD&E Laboratory personnel provided the following information:

- The 72-hour enclosed period for CVC's has been the figure of evaluation and planning for a number of years. It does not relate to any particular physical phenomenon (such as decay of NBC agents)

- In achieving the 72-hour enclosed operational period, there are three basic problems:

  - Food
  - Body waste
  - Body heat

- The microclimate vest provides ambient airflow to the crewman's face, torso and neck. Flow is 18 cubic feet per minute, (cfm), total: (3.5 cfm to the face, 14.5 to the torso). Excess air is dumped by a control valve which adjusts flow to the torso; the face gets a constant 3.5 cfm.

- The microclimate vest (MIL-V-44132) has been manufactured by Point Blank Body Armor (a commercial company).

- Macrocooling of the entire vehicle interior is not economical and not planned.

- In air-cooled vests, one size fits all; in liquid vests sizing is an important factor since heat is removed through conductivity.

- The air movement provides comfort in breathing and is less susceptible to malfunction and failure due to leakage.

- Information on the various levels of protective clothing for NBC environments is found in FM 21-40. In the fully protective posture, (MOPP-4) the soldier wears: overgarment, overboots, mask/hood, and gloves

5.7.4.5. TACOM, Warren, Michigan
Access was given by TACOM to INVOTEC to dimension the interior of the M1A1 tank.

5.8 Sleep Psychology

To assess the psychological aspects of the sleep/rest issues, INVOTEC engaged a licensed clinical psychologist, Dr. Michael Stevenson, PhD to provide inputs to the study in four areas. His tasks and the highlights of his analyses are given below:

5.8.1. Rest/Relaxation/Sleep Training Syllabus. Sleep training would be given to combat vehicle crews during their normal training course. The training would explain the effects of sleep deprivation, would instruct in coping techniques and would include selection of personal cassette tapes by individuals for their future use in vehicle confinements.

Without sleep, within 24 hours, both cognitive and vigilance tasks begin to deteriorate. The situational insomnia experienced by most crewmen deprived of sleep is a direct result of the stress of confinement and the lack of a positively conditioned sleep environment. Trainees would be informed of these situations and the effects demonstrated.

In setting up a rest/relaxation/sleep training program it is important to pay attention to the role individual differences have in regard to what is considered stressful and what is considered to be the most adaptive coping response. Each crewman is different in both areas.

Dr. Stevenson offered these suggestions for training:

- Flexibility in adapting to confinement should be encouraged to accommodate for individual differences

- Training should aim at making the confinement stress gradually more and more familiar (inoculation theory)

- Training should focus on reinforcing the social support network of the crew (mutual support)

- Open and honest relationships must exist between individuals, trainers, leaders to be sure all involved understand the true feelings of trainees

- Training should incorporate relapse prevention exercises to identify possible high-risk situations which may overstress the individual (unforeseen risk situations)

- The length of training is best based on performance criterion rather than a time-based criterion: for example, ability to function effectively for 72 hours of confinement rather than a fixed number of sessions

- Since this kind of training has no precedent, its details should evolve empirically, using control groups to try approaches and evaluate success

Psychologically, three states of training seem involved:

5.8.1.1. Education. This would be an assessment of how the individual experiences the stressor, including what the crewman may be thinking when confronted by the stressor. Currently available coping responses are explored. A model of stress and coping is introduced to emphasize the transactional nature of stress and coping.

5.8.1.2. Teaching general coping strategies. Crewmen will be taught how to prepare cognitively for the stress of combat vehicle confinement, how to confront this stressor while it is actually occurring, how to prepare for the possibility of being overwhelmed by the situation, and how to reinforce themselves for having coped.

5.8.1.3. Application of coping skills. This involves application of coping skills (imagery, rehearsal, modeling) in graduated exposures to actual confinements.

5.8.1.4. Rest/Relaxation/Sleep Training Concepts. The first effort is to systematically assess, with the cooperation of the individual crewman, the range of problems that confront each of them during their confinement.

5.8.1.5. Reconceptualization. The transactional nature of stress and coping will be introduced to:

- Demonstrate how individuals co-create difficulties in the face of environmental demands by their thoughts and feelings

- Present the ABC model of emotional disturbance

Crew member stress symptoms (body complaints, negative thoughts, feelings, and maladaptive behavior) will be translated into solvable problems rather than being overwhelmed by uncontrollable circumstances.

5.8.1.6. Skills Training. Relaxation skills to reduce physiological arousal will be introduced. These include progressive muscle relaxation, self-hypnosis, imagery and breathing exercises.

A personally tailored cassette tape program, combining various relaxation techniques will be selected for later use in actual combat vehicle confinement.

5.8.1.7. Strategies to Reduce Negative, Stress-Producing Thoughts. Coping strategies will be introduced, to include:

- Self-monitoring of negative stress engendering thoughts about prolonged confinement

- Identification of cognitive errors (i.e., over-generalization, all-or-nothing thinking, catastrophizing, etc.)

- Thought stopping of negative, nonproductive thinking

- Inoculation against future failure to cope

5.8.1.8. Sleep Hygiene Skills to Induce and Maintain Sleep. These include:

- Physical and mental relaxation skills for sleep onset

- Stimulus control training to reduce negative conditioning to sleep

- Sleep conditioning routines: perform certain physical/ physiological actions associated with sleep

- Sleep conditioning programming; psychological mental preparation, sleep-inducing audio tape

5.8.1.9. Application and Follow-through Phase. These efforts include:

- Set up stress hierarchy combining length of confinement and environmental stress (temperature, under attack, bodily discomfort, etc.
- Give least stressful "scene" a value of one and the most stressful on a value of 10.
- Use coping imagery beginning low in hierarchy and working up to more stressful scenes, imagining stress, imagining accompanying stressful thoughts and using coping skills.

5.8.1.10. Modeling. Trainees will watch a film (or video recording) of other crewmen undergoing confinement stress as they voice their thoughts and feelings while illustrating coping techniques. Trainees will discuss reactions to the film and what was learned from other crewmen's coping efforts.

5.8.1.11. Graduated Exposure to Stress. Crewmen will be placed in actual vehicle confinement for less than the goal time (i. e., 6 hours). This will be followed by a debriefing to include skill refinement and relapse prevention. Crew confinement will be increased by 6-hour intervals until the desired confinement length is reached. A debriefing will follow each confinement period. Combat stress may be added to confinement in a graded manner after confinement has reached maximum. Follow-up "booster" confinements should be given every 3 to 6 months to maintain the skill level.

5.8.2. Screening Test for Crews. A test or examination procedure which could be used to determine suitability of potential combat vehicle crewmen to withstand confinement in a vehicle up to 72 continuous hours might include:

5.8.3. Sleep Equipment Effectiveness Questionnaire. The questionnaire will be used to gather user evaluation data from field trials of sleep/rest equipment, a questionnaire will be developed for CVC response. The questionnaire will be in the form of a debriefing outline addressing such issues as ease of installation, use cycle, sleep/rest quality, suggestions and improvements.

One possible type of data form is the "semantic differential" (SD) questionnaire, first developed as a tool for research on the psychology of word meaning. The SD format has been

applied in many different contexts including product evaluation and should serve well in this context. Each piece of equipment can be rated on a seven-point graphic scale as being more closely related to a pair of opposites, as shown in the example below:

EQUIPMENT RATING SHEET

HARD TO INSTALL	__: __: __: __: __: __:	EASY TO INSTALL
POORLY DESIGNED	__: __: __: __: __: __:	WELL DESIGNED
FRAGILE	__: __: __: __: __: __:	DURABLE
BULKY	__: __: __: __: __: __:	COMPACT
WORTHLESS	__: __: __: __: __: __:	VALUABLE
HEAVY	__: __: __: __: __: __:	LIGHT
UNCOMFORTABLE	__: __: __: __: __: __:	COMFORTABLE
STRESS PRODUCING	__: __: __: __: __: __:	STRESS REDUCING

5.9. Outline of Proposed Phase II Program

5.9.1. General Scope of Work. The problem of combat vehicle crew performance degradation due to sleep loss and lack of relaxation under the continuous battle envisioned for the U. S. Army is an immediate and severe problem. Current vehicles do not have space for extensive modifications to provide the needed habitability features which will assure combat vehicle crews satisfactory, restorative sleep over the 72-hour (and perhaps longer) period now envisioned.

The Phase I work reported herein identified concepts which can be retrofitted to the three combat vehicles of concern in the study (M1, M2 and M3) to provide immediate relief by providing the crew a measure of body comfort and psychological techniques for coping with the highly stressful events involved in continuous operations.

The Phase I study also identified habitability issues which apply to the present vehicles, but more importantly to vehicles of future consideration. Continuing work on the CVC sleep/rest problem needs to seek quickly the best possible

practical solutions to enclosed sleeping/resting and to get such equipment and techniques into the hands of armored troops shortly.

A fully functional solution to the enclosed CVC sleeping and resting problem needs to address the habitability aspects of future vehicles. These need to be designed with self-contained living as a tactical requirement. The future combat vehicle crew compartment has to be seen as a closed system, in the same manner as an aircraft, deep-diving submersible, or spacecraft. Nothing less than this approach will protect the crew enclosed in their vehicle under NBC threat.

In the future vehicle, air conditioning is in no way an item of creature comfort. Temperature and humidity controlled air around the crewman's body is essential to prevent heat stress casualties, particularly when dressed in the MOPP-4 protective garments. Pure air for breathing is essential to long-term quality of mental processes, to correct interpretation of information, and effective decisions by leaders. Pure air is not merely filtering to remove particles, but control of gaseous levels, particularly carbon monoxide and carbon dioxide, are not just desirable but vital in long-term enclosed operations.

Food and water for 3-5 days, while enclosed need to be included. Waste management, not just collection and periodic dumping, is needed. New techniques to quickly change the properties and toxicity of waste products are needed to process the waste into benign, unobjectionable, and hopefully recyclable material.

Future vehicles need to be designed with long-term enclosed operations as a basic requirement. Future vehicle systems need to provide pure air, cool/warm environment as appropriate, and more functional seating with built-in features to allow restorative sleeping in the vehicle. The whole range of physiological and psychological affectives in the sleep problem need to be addressed.

INVOTEC sees four lines for continuing development of solutions to the CVC sleep/rest problems, and recommends each line be pursued by the appropriate Army agency having cognizance of the area involved:

- Service evaluation of the sleep/rest appliances and techniques identified in the Phase I work
- Militarization of selected appliances and techniques, preparation of technical data

packages allowing competitive procurement and procurements to support fielding of the selected items

- Design of habitability features for retrofit of existing combat vehicles, including "window-shade" Sling-Harness, underseat/overseat stowage means for sleep/rest appliances, new seat cushion having stowage built-in, added water reservoir with cooler, microclimatizer with air purification provision, MRE/water heater, intercom modifications for audio tape player use, etc.

- Establishment of habitability design criteria for future vehicles, including the design of a new CVC seat having built-in habitability characteristics as well as improved tactical utility

INVOTEC can assist in certain aspects of each of the above lines of effort. INVOTEC has proposed a Phase II program continuing and extending the Phase I conceptual work, with the main objective of Phase II to provide service-proven sleep/rest hardware and sleep conditioning techniques for solution of the immediate problem faced by the crews of the existing types and models of armored fighting vehicles.

5.9.2. Sleep/Rest Equipment Design and Evaluation.

5.9.2.1. Detail Design. A final design will be documented by Level I drawings for the following hardware items:

- Modular Pad
- Sling-Harness
- Extendable Bar (Suspension/Exercise Device)
- Massage Device
- Communications Adaptor

Materials, construction, and attachment fittings, will be documented. Before issue to the field, INVOTEC will fabricate qualification models and subject these to environmental and structural testing to validate the adequacy and ruggedness of the designs for CVC use.

5.9.2.2. Field Test and Evaluation. Sufficient hardware will be procured to equip the following training and doctrinal installations with the number of vehicle kits indicated.

INSTALLATION	VEHICLE	NUMBER OF KITS
Fort Knox	M1	3
	M60	3
Fort Benning	M2	3
Fort Benning (or other TBD)	M3	3
Fort Irwin	TBD	6
Natick Labs	Eval	1
HEL/Aberdeen PG	Eval	1
TACOM	Demo	1
Fort Lewis	Eval	4
	TOTAL:	25 Kits

It is proposed that the hardware kits be deployed to the field for a period of 3 months under operational training conditions. After use, a detailed evaluation will be made of the utility of the equipment items as reported by the tactical troops.

INVOTEC will collect the data by interviews, using standardized questionnaires and free-form discussions with the vehicle crews and commanders. INVOTEC will collect the data and evaluate these to establish findings and recommendations for the Army sponsor.

5.9.3. Communications Integration. This effort will provide hardware which will allow audio-cassette players to be integrated into any individual crew headset or as all-station messages on a channel of the vehicle intercommunications system.

5.9.4 Cassette Tape Programs. INVOTEC will provide a library of cassette tape programs suitable for the CVC application. The tapes will contain in-place exercises, relaxation training, relaxation imagery, and selected training or entertainment programs suitable for the CVC audience.

5.9.5. CVC Training Program.

5.9.5.1 Vehicle Confinement Training. INVOTEC will prepare. a training program which is specifically directed to armored vehicle crew confinement for extended periods in an NBC environment. The program format can be a training manual, class outline or a videotape presentation. The training protocol would be developed by a practicing professional psychologist with prior military service in the U. S. Marine Corps.

The training program would prepare the crews by orientation in the experience of others, testing to screen crewmen for individuals with potential problems in coping with confinement with special conditioning of these persons, then gradually increasing simulation of expected conditions during confinement, and finally, actual enclosed operations over increasingly extended periods and increasingly stressful conditions until the crew is qualified for 72 hours continuous confinement under simulated battle conditions.

5.9.5.2. Sleep/Rest Equipment Training. A manual will be prepared which illustrates all the features of the sleep/rest equipment, recommends combinations for use within the vehicles of interest, and describes various installation methods. The purpose of the training manual will be to encourage innovative and imaginative use of the equipment by the crewmen.

5.9.6 Vehicle Habitability Improvement.

5.9.6.1. Future Seat System. The Phase I study identified a need for future vehicles to contain a seat system which is multi-functional and provides provisions for extended habitability within the combat vehicle. The seat system should follow the philosophy of aircraft-crew-ejection seats, where the vehicle has a requirement to accommodate the seat and the seat is a separately procured system.

The proposed CVC seat will have self-contained features giving the user the minimum elements of habitability. It will include provisions for tactical employment in head-in/head-out modes and other improvements in operational suitability as well as the habitability features. The seat will rotate, elevate and recline in available space to form a sleep couch. It will include provision for waste disposal, personal hygiene and stowage of associated gear. Seat system concepts will be generated that are compatible with future vehicle interior spaces and crew functions.

Specific examples OF INVOTEC seat concepts are contained in the Phase II proposal.

5.9.6.2. Environmental Control. While it is impractical to provide global macroclimate control of existing vehicles' interior spaces, vehicles of the future should consider an encapsulated and sealed, self-contained, inner crew compartment which is easily insulated and environmentally sealed. Several concepts for these capsules will be formulated including umbilical connections, feed-through of sensors, etc., and weapon interfaces.

5.9.6.3. Subsistence and Waste Disposal. Current vehicles do not have provisions for 3 days of subsistence nor waste management utilities for this period of confinement. Work to date has attempted to use existing waste collectors as now handle the problem in recreational vehicles and small boats. For total confinement of 3-5 days the crews must be provided food, water, waste removal, sanitation and perhaps clothing exchange (or at least expendable insert exchanges). Designs to incorporate equipment for handling these amenities will be generated. Extensive experience from spacecraft and aircraft techniques will be utilized. Waste product rapid dehydration, decomposition and detoxification techniques will be applied with the goal of reducing solid waste to a harmless powder which can be dumped out through one-way ports.

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BIBLIOGRAPHY

Caldwell, Lee S., "Serial Isometric Fatigue Functions with Variable Intertrial Intervals," U. S. Army Medical Research Laboratory, Fort Knox, KY (USAMRL-886), (5 August 1970).

Dudeck, Richard A., "Performance, Recovery and Man-Machine Effectiveness", Semiannual Progress Report to Contract DAAD05-69-C-0102, (15 March 1971)

Kopstein, Felix, Siegal, Arthur, et al, Research Note 85-68, "Soldier Performance in Continuous Operations: Administrative Manual for a Briefing and Seminar for Platoon and Squad Personnel," Army Research Institute Field Unit at Fort Benning Georgia, U. S. Army Research Institute for the Behavioral and Social Sciences, (July 1985)

Kopstein, Felix, et al, Research Note 85-70, "Soldier Performance in Continuous Operations: Administrative Manual for a Briefing and Seminar for Platoon and Squad Personnel, "U. S. Army Research Institute for the Behavioral and Social Sciences, (July 1985),

Meichenbaum, D. & Jaremko, M. E. (Eds) "Stress Reduction and Prevention," Plenum Press, New York (1983)

Meichenbaum, D. "Stress Inoculation Training," Pergamon Press, New York, (1985)

Shaker, Steven M. and Wise, Alan R.,"Helping Fighting Men Keep Cool: Microclimate Conditioning", National Defense Magazine, (September 1985)

Simpkin, Richard E., "Human Factors in Mechanized Warfare," Brassey's Publishers Limited, New York (1983)

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